Vol. XXXVII October - November, 1953 Nos. 5 - 6

# THE PHILIPPINE AGRICULTURIST

UNIVERSITY OF THE PHILIPPINES PUBLICATIONS SERIES A

## CONTENTS


Loyalty to Life ..... *Harry A. Brenn* 221
Cadang-cadang of Coconut ..... *G. C. Kent* 223
Some Statistical Aspects of the Use of Composites in Soil Sampling ..... *Burton T. Oñate* 241
Behavior of Squash Chimeras ... *J. M. Capinpin, V. D. Rodriguez, and J. G. Odejar* 253
Efficiency of Ammonium Phosphate and Ammonium Sulfate Fertilizers in Increasing the Fertility of Lipa Clay Loam Subsoil ..... *Rufino L. Santos and Nicolas L. Galvez* 273
The Control of the Most Important Coconut Pests in Eastern Indonesia .. *Tjoa Tjien Mo* 283
Cleft-Grafting Lanzones, Lansium Domesticum .. *Sergio T. de la Cruz and Leon G. Gonzalez* 295
Pollination of Vanilla Flowers by Hand ..... *Pedro A. David* 301
The Performance of Berkjala Sows from Second Farrowing to Weaning ..... *Dolan Albas* 306
Residual Effects of Varying Amounts of Fertilizer Combinations upon the Succeeding Yield of Corn *Valeriano C. Calma and Camilo N. Calacala* 311
The Influence of Length of Grazing on Egg Production ..... *Richard Pang* 317
Built-up Floor Litter for Brooding Chicks ..... *A. C. Campos and M. P. Cruz* 327
The Growth and Performance of ½ Holstein × ½ Red Sindhi Crossbred Cattle ..... *John M. Taylor* 332
Additional Data on the Breeding Habits of Red Sindhi Cattle ..... *Lino E. Nazareno* 339
A Plot Test of Five Strains of Wagwag Rice ... *Valeriano C. Calma and Onofre J. Cruz* 353
Case Report: Anthrax in the UP College of Agriculture ..... *G. V. Garcia* 359
College and Alumni Notes ..... 361


*Published by*

THE COLLEGE OF AGRICULTURE
AND CENTRAL EXPERIMENT STATION
UNIVERSITY OF THE PHILIPPINES

COMMONWEALTH MYCOLOGICAL INSTITUTE
2 NOV 1954

# The Philippine Agriculturist

(University of the Philippines Publications Series A)


Editor

L. B. UICHANCO, SC.D. ..... *Dean, College of Agriculture*

Managing Editor

G. O. OCFEMIA, PH.D. ..... *Professor of Plant Pathology*

Copy Editor

NORA J. CRUZ, A.B. ..... *Instructor in English*

Business Manager

JOSÉ M. CAPINPIN, PH.D. ..... *Associate Professor of Agricultural Botany*

Advisory Board

F. C. SANTOS, PH.D. ..... *Head, Department of Agricultural Chemistry*
VALENTE VILLEGAS, PH.D. ..... *Head, Department of Animal Husbandry*
FRANCISCO M. SACAY, PH.D. ..... *Head, Department of Agricultural Education*
LEON G. GONZALEZ, PH.D. ..... *Head, Department of Agronomy*
A. B. CATAMBAY, M.S. ..... *Head, Department of Agricultural Engineering*
SILVERIO M. CENDAÑA, PH.D. ..... *Assistant Head, Department of Entomology*
NICOLAS L. GALVEZ, PH.D. ..... *Acting Head, Department of Soils*


Authors of articles appearing in THE PHILIPPINE AGRICULTURIST are severally responsible for the opinions expressed therein.


THE PHILIPPINE AGRICULTURIST is published monthly, except in April and May, beginning with Volume 35, by the College of Agriculture and Central Experiment Station, University of the Philippines, Los Baños, Laguna. The subscription price is ₱6.00 a year in the Philippines and $4.00 (U.S. currency) elsewhere; the price of single copies, ₱0.75 in the Philippines and $0.50 (U.S. currency) elsewhere.

Business correspondence should be addressed to the Business Manager, THE PHILIPPINE AGRICULTURIST, College, Laguna, Philippines. All remittances should be made payable to THE PHILIPPINE AGRICULTURIST.

Communications for the editor should be addressed to the Editor, THE PHILIPPINE AGRICULTURIST, College, Laguna, Philippines.

Publications sent in exchange for THE PHILIPPINE AGRICULTURIST should be addressed: Library, College of Agriculture and Central Experiment Station, College, Laguna, Philippines.

Entered at the Post Office at College, Laguna, Philippines, as second-class mail matter.

# LOYALTY TO LIFE [1]

HARRY A. BRENN [2]

Thirty-five years ago, the United States was engaged in a world war fighting for principles we believed to be in danger. Among those principles was the right of self-determination of peoples. You were then a colony. On October 10, 1918, there came a call to volunteer under an "alien" flag. Here at Los Baños, not a person hesitated. As one, students and faculty stepped forward.

That was a long step toward freedom.

Filipinos, deep inside, have always been free men. Lapulapu saw in the armored cavalier a sign of potential conquest. He struck the first blow to perpetuate freedom. The brain and spirit of Rizal were dedicated to enlarge the salient of freedom. The pens of Marcelo del Pilar and Mabini and the swords of Bonifacio, Jacinto, Aguinaldo, Gregorio del Pilar, and many others were always pointed toward freedom.

I am proud that my country in the earliest days of the occupation announced a policy of independence. We made a promise, and we kept it. I cannot but believe that the event of October 10, 1918, was a demonstration of loyalty to a common cause—a loyalty to the ideals of the free nation and the free individual.

In accepting the invitation of my friend, Dean Uichanco, to be your guest and speaker today, I know that I am only a symbol. The invitation was extended to America and to the ideals our two peoples hold dear. And so, it is with humility and pride that for a moment I can be a symbol of America.

Since 1918, the right of self-determination of nations and the freedom of the individual have been challenged on several occasions. Recent history has recorded our common response at Bataan, Corregidor, and Korea. The threat today is greater than ever. But if the time comes and men again must stand up and be counted, I know that Filipinos and Americans will be found together in the ranks of freedom.

The threat is obvious when it rolls over a country in tanks. It is just as real when it lies within a nation feeding on the hunger and misery of its people. Unless we can halt poverty, disease, ignorance, we will be ready prey for frustration, hopelessness, and desperation. This trinity of evils often has led people to barter their freedom for the illusion of security. The sovereignty of more na-

---

[1] Miscellaneous Contribution No. 26. Address to the faculty and students of the College of Agriculture, University of the Philippines, on Loyalty Day, October 10, 1953.

[2] Director, United States of America Foreign Operations Administration in the Philippines.

[THE PHILIPPINE AGRICULTURIST, Vol. 37, No. 4, September, 1953, appeared July, 1954].
THE PHILIPPINE AGRICULTURIST, VOL. 37, NOS. 5-6, OCTOBER-NOVEMBER, 1953.

tions is threatened now by the inadequacy of their production than by the combined armies of Malenkov and Mao Tse-tung. As long as this "social cancer" is at work, the battle for independence is not won, and the nation must call again upon the loyalty of its citizens. This call is to fight the battle of the production indexes. It is a call for loyalty to the game of living rather than a struggle to the death. It calls for the hardest kind of patriotism—work and sweat. It is not glamorous, but it is equally vital and real.

Poverty has a large part of Asia in its grip. The Philippines is more fortunate than most of her neighbors. But here, too, the threat exists. As long as "men are out in the hills" we have concrete proof that the threat is real. The battle of the production indexes has made a beginning here. It has a long way to go before any armistice is called for.

. . . . . .

During the next few minutes, let us look at the record.

The national income of the Philippines is estimated to be about eight billion pesos. If the national income could be expanded by five per cent, the increase would amount to 200 million dollars. This is four times the annual aid figure mentioned in the Bell Report. Any program of foreign aid is designed to meet emergency situations. And in its nature, it is bound to be temporary. On the other hand, expansion of a nation's productivity is almost certain to be a continuing process. What, then, is the best way to increase the national output of the Philippines?

There are many answers. It is not the plan of our Joint Mission, the Philippine Council for United States Aid and America's Foreign Operations Administration, to fight the battle of production from a single position. Projects are under way in the sectors of health, education, industry, labor and productivity, public works and roads, agriculture and natural resources, fiscal and trade policy, and public administration. The Joint Mission of PHILCUSA-FOA is leading attacks from all of the arcs of the perimeter.

To help win the battle of production, the importance of the University's College of Agriculture at Los Baños was recognized early in the program of the PHILCUSA-FOA Mission. Through June 30, 1953, almost one million dollars and more than two and one-quarter million pesos had been authorized for this College. Our Joint Mission has financed thirteen new faculty homes, eight of which are occupied by professors supplied under the UP-Cornell contract. You also have a new Agricultural Economics building, a new Home Technology building, and a new Soils building. There are minor structures, too, such as poultry shelters, battery brooders, commercial poultry houses, greenhouses, and the like. All of these have been completed and are in use.

A number of other important additions are being made in your campus. There is a new library building, a dormitory for girls, an Agronomy main building, a food processing building, and a building

to house the machinery of your Experiment Station. Including large and small units, forty new buildings have been added or are now in varying stages of completion.

Plans have been drawn and funds programmed to construct a new power plant. Thousands of books and periodicals have arrived and more will be added. Modern laboratory equipment and classroom fixtures are here and more are enroute. Farm implements and purebred animals are at hand. The College of Agriculture and Central Experiment Station, in terms of enviable facilities, will soon stand comparison with the best in this part of the world.

But you and I know that physical facilities do not constitute a college. They are only the means to create a college. They are the log to which a Socrates must be added. The essential ingredient that converts an inanimate mass of buildings into an institution of higher learning is the human factor. The intelligence, the training, the vision, the ambition, and the dedication of the men who comprise the staff determine the quality of its end product. And that end-product—the students—holds the key not only to the expansion of a national income, but to a country's future as well.

It is on the human factor that our Joint Mission is concentrating. Already many new teaching and research positions have been established. Nineteen research fellowship positions have been created. Two of your senior staff have been sent to the United States for advanced study and observation, and seven of your younger faculty members are scheduled to go. This policy of upgrading educational opportunities for students, graduates, and faculty will have our continuing efforts. We hope both to sustain and to broaden the policy. But this is not enough. The morale of the teacher is of crucial importance. We are convinced present salaries are too low; at the earliest opportune time we shall lend our efforts to improving them. We know that only when the minds of professors are free from pressing financial worries can they concentrate on the needs of their students.

During the brief interval since my arrival in the Philippines on this tour, I have heard good reports about the Cornell men on your campus. Cornell, as you know, is considered one of the finest universities of its kind. These men have been selected because of their competence in areas of your greatest need: Extension work, Plant Breeding, Plant Pathology, Agricultural Economics, Agricultural Engineering, Animal Husbandry, Soils, and Vegetable Gardening. When the full team of experts is working with your professors, it is an understatement to conclude that only teaching techniques and subject matter will be given new impetus. The greatest impact will be in the vital fields of research and extension. We are so convinced of this that we have already decided the initial two and a half year period of the UP-Cornell contract is not enough. At the request of President Tan and Dean Uichanco, we are moving to get it extended.

Is the investment in this contract justifiable? We think it is. Why not? The enrollment here reads like the chart of a successful

business: 1950—589; 1951—851; 1952—1,110; now—1,688. The number of students served has doubled since 1951; tripled since 1950. The buildings and facilities were designed for 3,000. It may well be that 3,000 was too small a target. There are many studies which prove that the correlation between investment in minds of young people and economic and social progress is positive and absolute. Developing the capacities of its youth is one resource no nation can afford to neglect.

. . . . . .

Up to this point, I have said that the basic problem of the Philippines is to expand the output of the Philippine economy. In the last analysis, this is a matter of changing basic thought and value-patterns of people. It is a matter of introducing better techniques and methods. In the most simple terms, it is a matter of education. Because this College is in a strategic position to discover, develop, and spread techniques of improvement, our Philippine-American Mission has made substantial improvements to your facilities and to your staff.

. . . . . .

Now I would like to tell you something about the PHILCUSA-FOA program as it relates to the entire Republic.

The American people have made available to the people of the Philippines loans and grants in excess of 100 million dollars. The Congress of the Philippines has authorized 120 million pesos.

What has been done, and what will be done, with the money?

Time will not permit me to furnish complete answers. The projects are too numerous for that. However, I shall give you a sampling of the work in process and contemplated in the areas of public health and education. Then I shall go into more detail with agriculture because this represents the area in which you have wisely chosen to invest so many of your years. In so doing, I shall try to point out some of the opportunities which are unrolling before you.

In our public health, the experts tell us that it is possible to add another twenty years to the life span of the average Filipino. Aside from compelling human reasons, extending the longevity of people expands the years of their productivity as well.

One PHILCUSA-FOA project aims to provide a healthful water supply; another to control malaria. Many of the provincial hospitals are being furnished with new equipment for anesthesia, surgery, laboratories, X-ray rooms, and the like. The Philippine General Hospital is slated to be one of the best-equipped teaching hospitals in the Far East. The College of Medicine of the University of the Philippines will have the latest in clinical, medical, and surgical apparatus. The Alabang Vaccine and Serum Production Laboratory is again turning out the vaccines and serums urgently needed to combat tuberculosis, typhoid, tetanus, and other major illnesses. Rural health units are being set up in the larger poblaciones. Barrios, too small

to warrant these expensive units, will have medical cabinets containing essential supplies. Our major target in this field is to keep people well. We believe that a centavo of prevention avoids the necessity of spending a peso to cure.

In education, the Mission is helping to rehabilitate the Central Luzon Agricultural College in Muñoz and the Mindanao Agricultural College in Bukidnon and to equip or construct many other vocational agricultural and vocational trade schools. Public normal schools are being assisted. FOA dollars are being channeled into UP's Colleges of Business Administration, Veterinary Medicine, Education, Engineering, Forestry, Medicine, Nursing, and Institute of Public Administration. To date, the Mission has sent one hundred forty Filipinos to the United States and other countries for additional training; one hundred fifty more have been selected.

We shall now go into more detail with projects of our largest program area, that of agriculture and forestry. Since April, 1951, when our program began, more than two hundred thousand Filipinos have used commercial fertilizers for the first time, and the rice crop of the past year was the largest ever harvested. As more farmers use compost and fertilizers, more seeds, irrigation, pest controls, and better land-management practices, the rice output will continue to expand. The same techniques can show similar production increases with corn and other crops.

The need to expand food production is a continuing need. To keep up with the growing population of the Philippines, it will be necessary to increase production an average of two per cent a year for many years to come. Also, there are thousands of people in the cities and on the land who would like to eat better if more food were available at reasonable prices. Finally, there is a world shortage of rice that shows no signs of diminishing while population increases every day by some fifty thousand mouths. So despite the fear of some well-meaning agricultural leaders, we see no reason to worry about a rice surplus in the immediate future.

As farmers intensify their efforts to produce more food and fibers, they must take proper care of the soil and protect the water that is essential to its fertility. The PHILCUSA-FOA program includes projects in soil conservation and in watershed protection in order to insure the continued productivity of the land.

Economic progress in any country has depended greatly upon expenditures for research. Here at Los Baños, we are assisting your scientists to strengthen their research in agriculture in order to discover new uses for the forest products of your country.

But research in itself will not raise the living levels of Filipinos. The results of research must be carried to the barrios and put into practice on the land. This is primarily the job of the newly created Bureau of Agricultural Extension. The Bureau has been given equipment to do the job. It now has *seven hundred fifty workers* in agriculture, home demonstration, and 4-H Clubs. It is planned to expand

this staff to thirteen hundred men and women. Here is a great opportunity for service to farm families and to the Philippines that is open to you young men and women of Los Baños. The Extension Bureau needs your youth, training, and enthusiasm.

Millions of dollars have been programmed to construct gravity irrigation systems. There are also tremendous possibilities for installing smaller irrigation systems powered by engines to pump water from rivers and streams. We have imported sixty pumps and engines for this purpose which are being installed at a speeded-up rate.

We are aware that rural people need greater incentives and greater resources to increase farm output and to give themselves greater incomes. There is need for cheaper production credit, marketing agencies under farmer control, and improved systems of land tenure. In Central Luzon and other older-settled areas, there are too many people on too little land. In Mindanao and in parts of Luzon, we find few people and large undeveloped areas.

The Joint Mission is giving assistance to settlement by surveying and dividing these areas into farmsteads and by building roads. We are also starting to speed up the issuance of titles to land ownership. But even if all the good farm land now idle could be settled, there would still be need to improve the tenancy conditions of the people who must continue to farm the older areas.

To provide credit to rural people, the Mission supported the enactment of the Rural Banks Act and the law which created the Agricultural Credit and Cooperative Financing Administration, better known as the ACCFA. Already twenty rural banks have started actual operation and eighty new agricultural cooperatives have completed their organization. They have already extended two million pesos to more than ten thousand Filipino farmers. The day of more adequate credit at reasonable rates appears to be dawning for the farmers of the Philippines.

. . . . . .

Let me close the circle on this address.

Poverty frustrates the legitimate aspirations of people for a better life. Alleviation of poverty is inherently connected with freedom and peace. Dollars and pesos are flowing into all sectors of the economy. Projects carrying great possibilities are underway. However, any program involving foreign aid—no matter how generous—can only be temporary. All it can do is to put the tools of economic improvement within the reach of another nation. *The burden of using these tools effectively falls upon the people themselves.* Progress cannot be imported. It can only be earned.

Thirty-five years ago today, the faculty and students of this College stepped forward as one man to offer themselves to a cause bigger than themselves. They were willing to die to make the world and their country a better place to live in. Here is a less dramatic opportunity for dedication. Raising the production indexes sounds

prosaic. Behind this dry phrase lies the hopes of people for a better life. Behind it, too, lies the way to a freer world. Behind it lies opportunity for yourselves. This is a call for another kind of loyalty—a loyalty to life—to a life with a deeper fuller content for you and for all other Filipinos.

# CADANG-CADANG OF COCONUT [1]

G. C. KENT [2]

WITH FOUR TEXT FIGURES

Cadang-cadang is considered to be the most serious threat to coconut production ever recorded in the Philippines. The slow but persistent early spread, the recent very rapid extension of the disease, the lack of any information as to the nature of the causal agent, and the absence of control measures combine to make cadang-cadang a very serious problem. The danger is especially serious since it involves the major crop of the Philippines.

A research program has been initiated and is underway. Unfortunately quick answers are expected. Considering the long life and the relatively slow growth of the coconut, the lack of basic information on the physiology and morphology of the coconut, and the difficulties of working with a monocotyledonous tree, it is doubtful that a solution will soon be found. The seriousness of the situation requires both intensive and extensive experimentation along all lines. Attempts to develop empirical control measures are especially desirable.

The available information is sketchy and somewhat contradictory and points to nothing definite in the nature of the cause or possible remedy.

## NAME

The name cadang-cadang is a local term signifying yellowing, growth failure, or running-out. The name is used in the Bicol region to indicate any yellowing or growth failure of any plant. Because of the importance of the coconut cadang-cadang, however, the term is rapidly becoming applied in a specific sense to that particular type of growth failure or yellowing found in coconuts in the Bicol peninsula. While also strictly applicable to the type of yellowing in coconuts resulting from poor drainage and probable nitrogen deficiency, it is more and more being restricted to apply to the present disease (Ocfemia, 1937; Celino, 1947a).

## SUSCEPTS

Positive identification of the disease even in coconuts is not, at present, possible. On the basis of the restriction in geographical distribution to cadang-cadang area and the general similarity in symptoms, the same or a very similar disease is believed to occur in

---

[1] Central Experiment Station Contribution No. 1722.

[2] Visiting professor of plant pathology (1952-1954) from Cornell University.

several other palms (De Leon and Bigornia, 1953). Among them are the following:

Buñga—*Areca catechu* Linn. (De Leon, 1951; De Leon and Bigornia, 1953; Calica and Bigornia, 1953).

Buñga de China—*Adonidia merrillii* (Becc.) Becc. (De Leon, 1951; De Leon and Bigornia, 1953; Calica and Bigornia, 1953).

Buri—*Corypha elata* Roxb. (De Leon and Bigornia, 1953; Calica and Bigornia, 1953).

Pugahan—*Caryota cummingii* Lodd. (De Leon and Bigornia, 1953; Calica and Bigornia, 1953).

Anahaw—*Livistonia rotundifolia* Mart. (De Leon and Bigornia, 1953).

Attempts to transmit the disease to 19 species of other plants and 3 species of palms, in addition to the coconut, have all failed so far (Calica and Bigornia, 1953).

## HISTORY OF THE DISEASE

Cadang-cadang is reported by growers to have been present in Nabua, Camarines Sur, as early as 1914 and in Calolbon, Catanduanes, since 1919 (De Leon, 1951; De Leon and Bigornia, 1953). The first survey of the disease was made by members of the Bureau of Plant Industry, but no report of it appears to have been published. The first published survey was that made by Dr. G. O. Ocfemia at the request of the Agusan Coconut Company on the San Miguel Island, Tabaco, Albay, in April, 1931 (Ocfemia, 1937). At that time the disease was not reported as serious in any area outside of San Miguel Island.

An additional survey and study of the disease was conducted on San Miguel Island in 1946 by Celino (1947a) who reported the disease as being present at that time in Albay around Tabaco, Bacacay, and Legaspi. As a result of this survey Celino instituted transmission studies. In his second report he mentioned obtaining specimens from Goa, Camarines Sur (Celino, 1947b). He reported the appearance of somewhat similar symptoms in seedling coconuts as a result of mechanical transmission. Celino's results have been repeated and confirmed. Since the plants, however, fail to develop typical cadang-cadang symptoms, these results have not been considered as proof of the transmissibility of the disease.

By 1950 the disease was reported as being present throughout the Bicol peninsula and serious in all provinces of the area (Reinking, 1950; De Leon, 1951).

## DISTRIBUTION

The typical cadang-cadang under consideration is reported to be serious throughout the Bicol provinces—Camarines Norte, Camarines Sur, Albay, Sorsogon, and Catanduanes. In addition, it has recently been found in Masbate, the northern and southern ends of Samar, and several of the small islands between Masbate, Samar,

and the Bicol peninsula (De Leon and Bigornia, 1953; Calica and Bigornia, 1953).

The disease has not been identified in any other province of the Philippines nor elsewhere in the world. Similar diseases reported in British West Indies, Ceylon, India, and Malay appear to be different diseases (Hansen, 1952).

### IMPORTANCE

Cadang-cadang was estimated to have caused a loss of ₱3,600,000 in copra alone in 1950. This loss is increasing all the time; strip surveys showed the disease to have destroyed an estimated 5,527,000 coconut trees by 1953 (Calica and Bigornia, 1953). If all these trees had been alive and producing at an average rate of ₱4.00 a tree, the additional income, or the loss occasioned by their destruction, in 1953 would have been about ₱22,000,000. This loss of ₱22,000,000 in a crop would have had an export value of ₱350,000,000 with a government revenue value of ₱7,500,000.

The records of the occurrence on the San Miguel Estate are indicative of the extreme destructiveness of the disease. Ocfemia (1937) reported that in 1931 in the most severely affected areas the infection reached 25 per cent. In 1946 the disease reached 85 to 90 per cent in four sections of the Estate, but only 2 to 3 per cent in the other two sections (Celino, 1947a). By 1950, in the first four sections, 80 to 100 per cent of the trees were affected in large areas. A few small areas showed 20 per cent infection. In one of the two sections showing 2 to 3 per cent infection in 1946 the general percentage of infection was 20, whereas in the other section it was 50 to 60 per cent. In both sections, areas of 80 to 100 per cent infection were found (Reinking, 1950). By 1953 the Estate Manager estimated that of 260,000 bearing trees at the peak of production, only 45,000 were still bearing. While some loss must be attributed to typhoon damage, the majority of the trees were killed by cadang-cadang (Reinking, 1950; De Leon and Bigornia, 1953).

The results of strip surveys through the Bicol provinces show a similar trend. The actual number of trees lost depends on the number of bearing trees in the area. With the Census of Agriculture figures for 1948 as a base, the trees destroyed by cadang-cadang in the Bicol area out of a total of 16,780,000 (Calica and Bigornia, 1953) are as follows:

| | | |
|---|---|---|
| 1951 | ..... | 1,788,000 |
| 1952 | ..... | 4,569,000 |
| 1953 | ..... | 5,527,000. |

### NATURE OF DAMAGE

The exact nature of the damage from cadang-cadang is not known. The loss of chlorophyll in nearly three-fourths of the leaves and the subsequent drying and dying of half these leaves must cause a considerable reduction in the production of carbohydrates. This

reduction is adequately shown in the reduction in size of the bowl, the marked reduction in starch stored in the bowl, and the failure to produce nuts (Ocfemia, 1937; Fajardo, 1953). The exact time from infection to cessation of nut production is not known. It is estimated that nut production ceases about one year after the appearance of the symptoms (De Leon and Bigornia, 1953).

### SYMPTOMS

A tree infected by cadang-cadang can usually be distinguished by its color, shape and fullness of the crown, tapering of bowl, and lack of fruit (Ocfemia, 1937; Reinking, 1950).

From a distance the lower two-thirds of the crown of a diseased tree appear off-yellow, bronze-yellow, or bronze rather than the normal dark green. The fronds do not show the true yellowing typical of trees in water-logged soils. The top third of the crown remains green (fig. 1) and may even be darker green than normal (Ocfemia,

Fig. 1.—A coconut palm (center) with all of the older leaves yellowed, photographed on April 8, 1953. The central whorl of leaves is dark green, but the difference in size between the young and the old leaves is not yet conspicuous. Note absence of nuts on trees. (*Photographed by R. H. Ocfemia in San Isidro, Bacacay, Albay.*)

1937; Reinking, 1950; Celino, 1947a; De Leon and Bigornia, 1953; Calica and Bigornia, 1953).

The young leaves in the center of the crown, in addition to being green, are short and tend to remain upright. In advanced cases they may fail to unfold and remain as an upright tuft in the

Fig. 2.—Different stages of cadang-cadang infection shown by the different trees on April 8, 1953. Lower left, a young stage showing only the yellowing of the leaves; upper left, almost the last stages of the disease. The yellowing of the lower older leaves is shown by the three palms to the right. Note absence of nuts on trees. (*Photographed by R. H. Ocfemia in San Isidro, Bacacay, Albay.*)

center of the crown, which appears as if cut off at right angles. There is always the tendency to a central upright tuft of shortened dark-green leaves. Each new leaf is shorter than its predecessor; thus there is a gradual persistent shortening of the crown fronds (Ocfemia, 1937; Reinking, 1950; De Leon and Bigornia, 1953; Calica and Bigornia, 1953).

In the late stages of the disease the center fronds, very short, stiff, and brittle, become bronze-yellow like the outer older leaves.

As the shortening of the new leaves progresses, the tufting becomes more evident because of the drooping and dropping of the lower oldest fronds. As the disease progresses the leaves become brown, and under a strong sun they suddenly dry out and appear blighted. These leaves droop before the sudden blighting and drop soon afterwards. The leaves are shed more rapidly (fig. 3) than on

Fig. 3.—Young bearing trees, photographed on April 8, 1953, badly infected with cadang-cadang. Only two trees have bunches of nuts which hang from broken peduncles. (*Photographed by R. H. Ocfemia in San Isidro, Bacacay, Albay.*)

healthy trees and more rapidly than new leaves are produced. Thus the leaves of the crown are decreased in number (fig. 2) as well as in size (Ocfemia, 1937; Celino, 1947a; Reinking, 1950; Calica and Bigornia, 1953; De Leon and Bigornia, 1953).

In the late stages of the disease the crown of the tree is reduced to eight to ten short, stiff, upright, bronze-yellowish leaves in a tuft at the top of the stem with a few drooping, dead, older leaves about to fall from the trunk. The growing point finally dies in two and

one-half to seven years and all leaves drop; a crownless trunk is all that remains (Calica and Bigornia, 1953).

During the reduction of the crown the trunk also shows evidences of the dwarfing effect of the disease. Trees in the middle or late stages of the disease show a marked tapering of the trunk just below the crown. The leaf scars on the tapered trunk area are closer together and are slightly smaller. There is some indi-

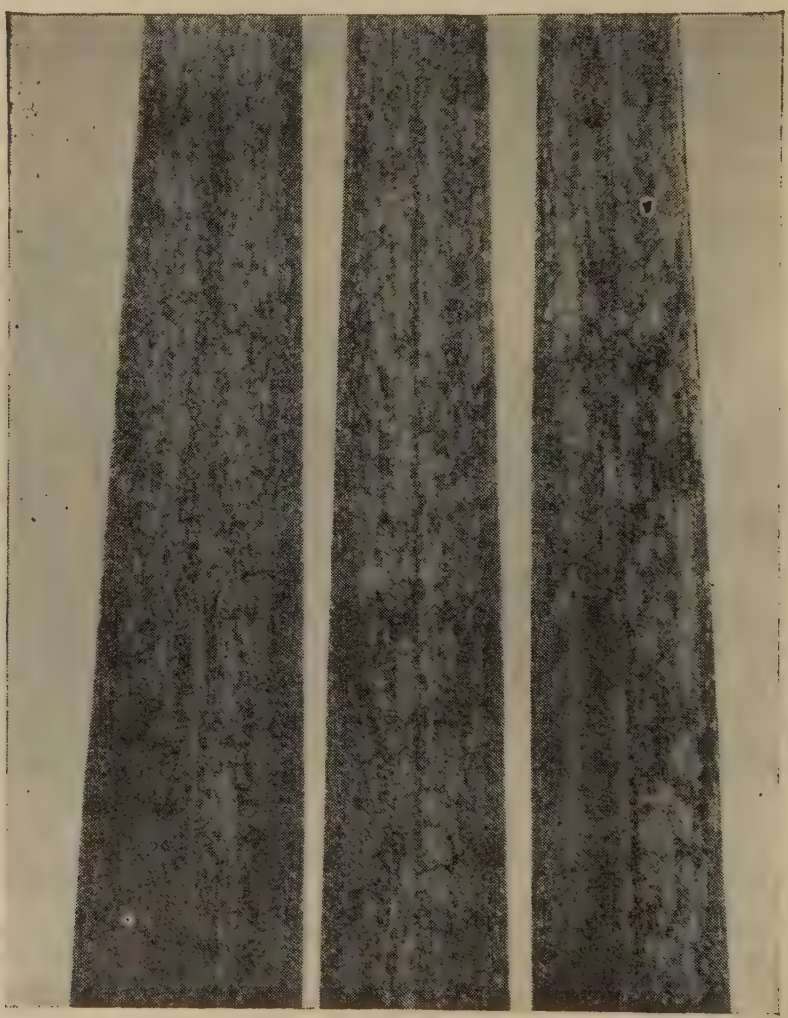


Fig. 4.—Three pinnae from the upper part of a leaf of a diseased coconut tree felled on the leased property of the Bureau of Plant Industry near the Nasisi River, Ligao, Albay, and photographed on April 13, 1953, using transmitted light. (*Photographed by the Photographic Division of the College of Agriculture.*)

cation that these two effects begin two to three years before leaf symptoms actually become clearly evident (Ocfemia, 1937; Reinking, 1950).

The first visible evidence of the disease is a decrease in size and quantity of nuts. Unfortunately this symptom is not diagnostic. The nuts become smaller and fewer and tend to be triangular rather than round. Shortly after leaf symptoms become fully evident, female flowers fail to form and the male flowers abort or drop off when the spathe opens. Thus about one year after the disease is first noted, nuts are no longer found on the tree (figs. 1, 2, and 3). The nuts on the last few inflorescences show a dry brown necrosis either on the basal third of the husks, near the stem, or as a band around the nut about one-third of the way from the pedicle. The meat fails to form and the nuts abort and drop (Ocfemia, 1937; Reinking, 1950; De Leon and Bigornia, 1953; Calica and Bigornia, 1953).

The most characteristic symptoms of the disease can only be seen by removing one of the leaves about one-third to one-half the way back from the center of the crown. The pinnae from such fronds when viewed in reflected light first show small water-soaked lesions (fig. 4) on the underside only. These lesions range from minute dots to a size of 2 mm. wide $\times$ 3 mm. long. At first the lesions are limited by the veins, but more dot-like, water-soaked areas appear which coalesce to produce larger, irregular, elongate, and blotchy water-soaked areas. While the water-soaked lesions tend to occur on the blade of the pinnae, they are also found on the midrib and petiole. These lesions look exactly like bacterial infections, but no bacteria can be seen in them nor cultured from them. These water-soaked lesions first occur on the second or third unfolded leaf. Until the leaves become quite old no necrosis is visible in the lesions (Ocfemia, 1937; Celino, 1947a; De Leon and Bigornia, 1953; Calica and Bigornia, 1953).

When viewed by reflected light from the upper surface, the pinnae of the seventh or eighth leaf show nothing. When the pinnae are viewed by transmitted light, however, the water-soaked areas appear yellowish. The areas change color, becoming bronze, and enlarge. The pinnae are narrower, shorter, more brittle, stiffer, with fluted, wavy, or crinkled margins; they tend to buckle just past the middle. All these leaf symptoms increase steadily until the leaf suddenly collapses and dies (Ocfemia, 1937; Celino, 1947a).

The milk from nuts of newly diseased trees tastes normal. Buds from the cabbage of such trees tend to be quite sweet (Reinking, 1950).

Cross sections of the trunk, even in the tapered area, reveal no evidence of morphological change. The ground tissue is white and apparently healthy and the vascular bundles are not discolored. The water-soaking occasionally found in the ground tissue at the top of the trunk and sometimes in the young buds in the crown

appears to be a result of typhoon damage rather than cadang-cadang. Microscopic examination of trunk tissues, as well as of leaf lesions, shows nothing indicative of any causative agent (Reinking, 1950).

Roots of trees in the early stages of cadang-cadang and active roots of trees in the more advanced stages appear normal. Coincident with reduction of the crown, death of roots also occurs. The cortex, in many cases, dies even while the stele still appears normal and functioning. In the late stages of the disease all kinds of organisms can be found in the dead cortical tissues. The picture is one of root starvation. The lack of starch, except at the top of the stem, would be circumstantial evidence of starvation (Ocfemia, 1937; Reinking, 1950; Fajardo, 1953).

Cadang-cadang has been reported as occurring only in bearing trees, eight to ten years or older. Recently leaf symptoms typical of cadang-cadang have been observed in 25 trees four to eight years old. Diagnosis in seedlings is difficult since nut production, crown symptoms, tapering of stem, etc., cannot be determined (De Leon and Bigornia, 1953).

The entire syndrome appears to point to an early and progressive destruction of the chlorophyll and a resultant starvation of the plant. No coconut trees have ever been known to recover from the disease.

### ETIOLOGY

The cause of cadang-cadang of coconut has not been determined. Considerable evidence has accumulated to indicate that the disease is not caused by a fungus, by a bacterium, or by insect feeding. No bacteria or fungi have been found in the leaf lesions or crowns either by microscopic observation or by culture methods. Spraying tests to control insects have not resulted in any diminution of the disease (Reinking, 1950; De Leon and Bigornia, 1953).

Several species of nematodes have been found in the crowns of trees in an advanced stage of cadang-cadang that are not found in healthy coconuts. The possible pathogenicity of the nematodes has not been tested (De Leon and Bigornia, 1953).

The two current theories concerning the cause of the disease are that it is caused by a virus or by a nutrient deficiency. The theory of the virus nature of the disease rests on the similarity of symptoms, the absence of a microscopic causal agent, the apparently infectious nature of the disease, its spotty distribution, the presence in areas of 90 per cent infection of healthy trees with roots feeding in the same area as the diseased trees, and the tendency of the disease to spread from foci of infection (Ocfemia, 1937; Celino, 1947a; Reinking, 1950; De Leon, 1951; De Leon and Bigornia, 1953; Calica and Bigornia, 1953).

Celino (1947b) reported mechanical transmission of the disease. His results have been confirmed. Since, however, the symptoms produced by such transmission are not typical of the disease as

seen in the field and do not develop into typical symptoms but, in fact, fail to appear in subsequently formed leaves of some plants, Celino's report of transmission of cadang-cadang has not been generally accepted as proof of the transmissibility of the disease. The disease in typical form has not been produced by mechanical transmission tests of many types. Grafting of coconuts has not been possible (De Leon and Bigornia, 1953; Calica and Bigornia, 1953).

Some indication of transmission by insects and pollen has been obtained. In tests with 36 species of homopterous insects and four species of beetles, indication of transmission has been reported with two species. One tree out of five tested with *Cicadella unimaculata* (Sign) showed symptoms in 242 days. Two trees of 10 tested with *Cicadella bipunctifrons* (Stal.) showed symptoms in 178 and 210 days. One of five checks for *C. unimaculata,* none of 10 checks for *C. bipunctifrons,* and none of 30 checks for the other species used in the test showed cadang-cadang symptoms. Because of the failure to find adequate symptoms in seedling trees, all such tests are run on standing trees in plantations (De Leon and Bigornia, 1953; Calica and Bigornia, 1953).

In tests utilizing pollen from trees infected with cadang-cadang, the disease appeared in 4 of 10 trees pollinated with normal pollen (Calica and Bigornia, 1953).

The theory of nutrient deficiency as the cause of cadang-cadang is based on the failure to transmit the disease either to palms or to several weeds found in plantations, the similarity of symptoms to nutrient deficiencies in other plants, the slow, progressing decline of the trees, the tendency of the disease to become serious in certain topographies, the claim that the disease does not spread from foci but is randomly distributed, and the supposition that infectious diseases spread uniformly and regularly from a central focus and not in a spotted pattern (Fajardo, 1953).

Adequate tests of nutrient deficiencies have not been conducted. Furthermore, nothing is known of the effects of nutrient deficiencies on the coconut or of its nutritional requirements. To date leaf analyses even of healthy coconuts have not been made in this area.

### LIFE CYCLE

In the absence of information about the causal agent, little can be said about the disease cycle. Some guess or indication of possible details has been suggested by some workers and is recorded here in order to give completeness to the literature review.

### INOCULATION

Celino (1947b) obtained transmission of what he considers the primary symptoms of cadang-cadang by pricking with fine needles through pinnae of infected fronds into the base of an unfurled leaf of a healthy seedling. The details of his experiment have been con-

firmed by others. This would indicate mechanical inoculation through wounds in young leaf tissue. As mentioned earlier, however, such inoculated seedlings do not develop normal symptoms of cadang-cadang.

Reinking (1950) pointed out that from the data from surveys on San Miguel Island by Ocfemia, Celino, and himself, it is evident that the disease spreads more rapidly in areas exposed to wind. These areas are also likely to be the areas of the poorer soils. Reinking also pointed out that since the disease does not occur in plants before the bearing age, the flower must be the inoculation court. While the basis for Reinking's statement is no longer entirely true, the finding of 25 infected trees less than eight years old in over 5½ million diseased trees and several hundred thousand non-bearing trees cannot entirely nullify his suggestion.

### INFECTION

The course of infection can only be inferred from the symptoms. The disease appears in the leaves in the third to seventh leaf positions, becoming fully evident only when they are in the seventh to eighth positions. All subsequently formed leaves show the symptoms when they in turn reach these positions in the crown. The disease becomes systemic in the early stages of its development; plants not only do not recover, but the severity of the disease steadily and persistently increases until death.

Reinking (1950) pointed out that seven- to eight-year-old trees planted in bady affected areas of the San Miguel Estate showed no sign of the disease even though adjoining trees 15 to 20 years of age were severely infected. He also observed similar healthy three- to four-year-old volunteers among diseased trees. De Leon and Bigornia (1953), however, reported about 25 diseased trees of four to eight years of age.

Calica and Bigornia (1953) pointed out the sudden heavy increase in diseased trees of 14.8 per cent from November, 1951, to July, 1952, compared to what is considered as the normal rate of 3.3 per cent, as for August, 1952, to July, 1953. The same relative rates of increase were noted in the detailed observations on etiological plots and in strip surveys. The authors noted a tendency for spread to center around foci of previous infection and concluded that there "appear to be certain agent or agents of spread" concerned.

There have been no histological studies of the leaf lesions nor of other portions of the infected plants. Such studies are badly needed.

### EPIPHYTOLOGY

No information is available in regard to the influence of environment on the disease. Because of the absence of equipment, no records are available from which even indications might be obtained. Celino (1947b) does record the observation of Mr. E. G. Macabeo,

then Superintendent of the San Miguel Estate, that frequent rains and strong winds favor the rapid spread and occurrence of the disease in severe form.

Lack of information on the nutritional requirements of the coconut and the effect of nutrients on cadang-cadang is extremely serious. The probability of the disease being caused by a nutritional deficiency or excess cannot be denied and must be determined. Even though the disease may not directly be caused by a nutrient disturbance, observations indicate that such disturbances undoubtedly have a large influence on the course of the disease.

## CONTROL

No control measures are known. In the absence of any reasonable indication as to whether the disease is infectious or noninfectious, decision on a provisional control program has not been reached.

Arguing from the fact that coconuts never recover and that the disease appears to be infectious in nature, Celino (1947a) and Ocfemia (1950) recommended that diseased trees be removed. When a diseased tree is located, an insecticidal spray should be applied to that tree and to all plants within a 100-meter radius. The tree should be cut down immediately afterwards and burned. After a reasonable time—six to nine months—the tree should be replaced with a healthy seedling. Until more is known of the relation of other plants to the disease, all ground cover should be removed from the plantations.

In the meantime experiments on possible control measures are underway. Those under test include clean culture, felling, spraying before felling, felling and scorching of green parts, and spraying, felling and scorching of green parts. Results on these experiments are not yet available (Calica and Bigornia, 1953).

In addition, a collection of coconut varieties and strains is being made with a view to the possible discovery of a resistant strain (Calica and Bigornia, 1953).

## BIBLIOGRAPHY

CALICA, C. A., AND A. E. BIGORNIA. 1953. The yellow mottle disease or coconut kadang-kadang and researches on its cause and control. Paper read at 8th Pacific Science Congress, U.P., Quezon City, Philippines, November, 1953.

CELINO, MARTIN S. 1947a. A preliminary report on a blight disease (cadang-cadang) of coconut in San Miguel Estate, Albay Province. Philippine Jour. Agric. 13: 31–35.

CELINO, MARTIN S. 1947b. Progress report on experimental transmission of cadang-cadang disease of coconut. Philippine Jour. Agric. 13: 109–111.

DE LEON, DONALD. 1951. Report on studies of a disease (yellow mottled or infectious kadang-kadang) of the coconut tree in the Philippines. Mimeographed.

De Leon, Donald, and Avelino E. Bigornia. 1953. Coconut kadang-kadang disease in the Philippines and experimental control program. U. S. Mutual Security Special Technical and Economic Mission, Manila, Philippines. Mimeographed.

Fajardo, Tranquilino G. 1953. Study on coconut diseases. I. Report on certain observations and experiments on the study of cadang-cadang and other maladies of coconut in the Philippines. Paper read at 8th Pacific Science Congress, U.P., Quezon City, Philippines, November, 1953.

Hansen, Henning P. 1952. On the so-called "unknown disease" and related diseases on coconut palms in the West Indies. Plant Disease Reporter **36** (2) : 66–67.

Ocfemia, G. O. 1937. The probable nature of cadang-cadang disease of coconut. Philippine Agriculturist **26**: 338–340.

Ocfemia, G. O. 1950. Measures suggested for the control of the infectious form of cadang-cadang disease of coconut. College of Agriculture Biweekly Bull. **15** (1) : 1–2.

Reinking, Otto A. 1950. Preliminary report on the cadang-cadang disease and on soil deficiency troubles of coconut in the Philippines. Plant Disease Reporter **34** (10).

# SOME STATISTICAL ASPECTS OF THE USE OF COMPOSITES IN SOIL SAMPLING [1]

BURTON T. OÑATE

The technique of the analysis of variance was used to evaluate the efficiency of the use of composites in soil sampling. Estimates were given and some suggestions made on the proper sampling of field plots. Work of this nature is currently being conducted at the UP College of Agriculture and Central Experiment Station in Laguna.

In many field experiments the choice of the optimum size of the experimental unit is governed by many factors. When a plot of a given size and shape is taken as an experimental unit, it is often not possible or feasible to measure the characteristic under study, say, soil moisture, on the whole of each experimental unit. A sampling unit or a random sample of the unit must therefore be chosen from which to gather data that can give the required information.

A common practice in soil sampling is to take two or more borings from a plot and then mix these individual borings thoroughly into a single soil mass called a composite. One or more subsamples are taken from the composite and each subsample is analyzed for the soil property under study on the assumption that a result from the composite is a valid estimate of the mean of results from the individual borings. The size of the composite is determined by the number of contributing borings; thus, an individual boring may be termed a composite, the number of contributing borings being one.

This paper describes some of the statistical aspects relevant to the use of composites in soil sampling.

Considerable literature on the subject is available. Much of it is concerned with soil surveys of large areas or rather large fields (Youden and Mehlich, 1937; Rigney and Reed, 1945; Reed and Rigney, 1947). Principles and methods of collecting and preparing soil samples have been given (Cline, 1944; 1945). Very recently, Jacob and Klute (1952) in Cornell University determined the relative magnitudes of sources of variation of various chemical and physical properties of the soil from an organic amendment experiment.

## THEORETICAL ASPECTS

The areas of soil considered in this sampling study were plots in a replicated field experiment. In general, each individual plot at some specified depth was designated as a sampling area. Estimates

[1] Central Experiment Station Contribution No. 1723. Based on a portion of the writer's unpublished work entitled, "Methods of Sampling Soil from Replicated Field Experiments." Read at the scientific meeting of the Los Baños Biological Club, October 30, 1953.

of one or more soil characteristics were made for each plot. The sampling unit (s.u.) was either an individual boring or a composite of several borings. Tubes with a diameter of 0.75 of an inch (1.905 cm.) were used to make the borings. The sample for any one plot was considered to be the aggregate of all the sampling units (s.u.'s) taken within the plot.

In estimating the variances for different samplings within plots, the finite corrections were ignored. In a plot one-fifteenth of an acre (about eighty-two sq. m.) in size there are approximately 287,478 s.u.'s of individual borings. Even if the sample contained as many as 100 borings, the sampling rate would be only 0.000348.

For a valid estimate of the sampling error, the s.u.'s were taken at random. Estimates of the variance due to different sources of variation in replicated field experiments were evaluated by the analysis of variance. With this technique, valid estimates of error were obtained. The interested reader is referred to the works of Mann (1949), Cochran and Cox (1950), Fisher (1951), and Kempthorne (1952).

In a replicated field experiment of $r$ randomized blocks consisting of $p$ plots (treatments), a random sample of $s$ sampling units from each plot was taken. The chemical or physical property of the soil under study was determined by individual analysis of each sampling unit.

Let $x_{ijk}$ be a particular result of an individual analysis, where $i$ denotes the block or replicate ($i = 1, 2, \ldots, r$), $j$ the plot or treatment ($j = 1, 2, \ldots p$), and $k$ the sampling unit ($k = 1, 2, \ldots s$). The model is

$$x_{ijk} = \mu + r_i + p_j + \alpha_{ij} + \delta_{ijk} \qquad (1)$$

where

$\mu$ = the general mean
$r_i$ = the block effect
$p_j$ = the plot effect
$\alpha_{ij}$ = the experimental error of plot $(ij)$
$\delta_{ijk}$ = the sampling error of $k^{th}$ analysis on the $(ij)^{th}$ plot.

The following conditions are imposed. The expectations of $\alpha_{ij}$ and of $\delta_{ijk}$ are zero, and the $\alpha_{ij}$'s and $\delta_{ijk}$'s are normally and independently distributed with common variances $\sigma_e^2$ and $\sigma_s^2$, respectively. Because of random sampling, the $\alpha_{ij}$'s are independent of the $\delta_{ijk}$'s.

With the above additive model, the analysis of variance on a sample basis is as follows:

*Analysis of variance* (I)

| SV | DF | SS | MS | E(MS) |
|---|---|---|---|---|
| Replicates | $(r-1)$ | $\frac{1}{ps}\Sigma X_{i..}^2 - C$ | | |
| Treatments | $(p-1)$ | $\frac{1}{rs}\Sigma X_{.j.}^2 - C$ | $T$ | $\sigma_s^2 + s\sigma_e^2 + \frac{rs}{(p-1)}\Sigma(p_j - p.)^2$ |
| Experimental error | $(r-1)(p-1)$ | $\frac{1}{s}\Sigma X_{ij.}^2 - \frac{1}{ps}\Sigma X_{i..}^2 - \frac{1}{rs}\Sigma X_{.j.}^2 + C$ | $E$ | $\sigma_s^2 + s\sigma_e^2$ |
| Sampling error | $rp(s-1)$ | $\Sigma_{ijk}(x_{ijk} - \frac{X_{ij.}}{s})^2$ | $S$ | $\sigma_s^2$ |
| Total | $rps-1$ | $\Sigma_{ijk} x_{ijk}^2 - C$ | | |

where

$$X_{ij.} = \Sigma_k x_{ijk}$$

$$X_{i..} = \Sigma_{jk} x_{ijk}$$

$$X_{.j.} = \Sigma_{ik} x_{ijk}$$

$$X_{...} = \Sigma_{ijk} x_{ijk}$$

$$C = x_{...}^2/rps.$$

If $\Sigma\frac{(p_j-p.)^2}{(p-1)} = \sigma_t^2$, then $\frac{rs}{(p-1)}\Sigma(p_j-p.)^2$ is written as $rs\sigma_t^2$. The test for significance of treatments is the F-test of $T/E$ with $(p-1)$ and $(r-1)(p-1)$ degrees of freedom.

The components of variance $\sigma_s^2$ and $\sigma_e^2$ are estimated by $S$ and $\frac{E-S}{s}$, respectively. The estimated variance of a treatment comparison on a per sample basis will be proportional to $E/rs$. The estimate of the variance of a treatment comparison with $r'$ replicates and $s'$ sampling units per plot is proportional to

$$\frac{S}{r's'} + \frac{(E-S)}{r's} = \frac{1}{r'}\left\{\frac{S}{s'} + \frac{(E-S)}{s}\right\}. \qquad (2)$$

Estimates of the variance of any treatment comparison with varying values of $r'$ and $s'$ are calculated from the above formula, provided that $S$ and $(E-S)/s$ are assumed to be accurate estimates of $\sigma_s^2$ and $\sigma_e^2$, respectively. The reduction or the increase in the estimated variance may now be computed for any two or more arrangements of $r'$ and $s'$.

A slight modification of equation (1) is presented for evaluating the use of composites (number of borings greater than one) in soil sampling.

In an experiment of $r$ randomized blocks containing $p$ plots or treatments with $m$ composites in each plot and $s$ subsamples from each composite, let $x_{ijkl}$ be the subsample observation, where $i$ and $j$ are as in equation (1), $k$ the composite ($k = 1, 2, \ldots, m$), and $l$ the subsample ($l = 1, 2, \ldots, s$). The new model is

$$x_{ijkl} = \mu + r_i + p_j + \alpha_{ij} + \delta_{ijk} + \xi_{ijkl} \qquad (3)$$

where $\mu$, $r_i$, $p_j$, $\alpha_{ij}$ are denoted as in equation (1),
$\delta_{ijk}$ = the composite error of the $k^{th}$ composite on the $(ij)^{th}$ plot,
$\xi_{ijkl}$ = the subsampling error of the $l^{th}$ observation on the $(ijk)^{th}$ composite.

The expectations of $\alpha_{ij}$, $\delta_{ijk}$ and $\xi_{ijkl}$ are zero, and the $\alpha_{ij}$'s, $\delta_{ijk}$'s, and $\xi_{ijkl}$'s are normally and independently distributed with common variances, $\sigma_e^2$, $\sigma_b^2$, and $\sigma_s^2$, respectively.

The analysis of variance for equation (3) is as follows:

*Analysis of variance* (II)

| SV | DF | SS | MS | E(MS) |
|---|---|---|---|---|
| Replicates | $(r-1)$ | $\frac{1}{pms}\Sigma X_{i}^{2} - C$ | | |
| Treatments | $(p-1)$ | $\frac{1}{rms}\Sigma X_{j}^{2} - C$ | $T$ | $\sigma_s^2 + s\sigma_b^2 + ms\sigma_e^2 + rms\sigma_t^2$ |
| Experimental error | $(r-1)(p-1)$ | $\frac{1}{ms}\Sigma X_{ij}^{2} - \frac{1}{pms}\Sigma X_{i}^{2}$ | | |
| | | $- \frac{1}{rms}\Sigma X_{j}^{2} + C$ | $E$ | $\sigma_s^2 + s\sigma_b^2 + ms\sigma_e^2$ |
| Among composites | $rp(m-1)$ | $\frac{1}{m}\Sigma X_{ijk}^{2} - \frac{1}{ms}\Sigma X_{ij}^{2}$ | $C$ | $\sigma_s^2 + s\sigma_b^2$ |
| Subsampling error | $rpm(s-1)$ | $\Sigma_{ijkl} (x_{ijkl} - X_{ijk/s})^2$ | $S$ | $\sigma_s^2$ |
| Total | $rpms - 1$ | $\Sigma_{ijkl} x_{ijkl}^2 - C$ | | |

where

$$X_{ijk.} = \Sigma_{1\ ijkl} x$$

$$X_{i...} = \Sigma_{jkl\ ijkl} x$$

$$X_{.j..} = \Sigma_{ikl\ ijkl} x$$

$$X_{....} = \Sigma_{ijkl\ ijkl} x$$

$$C = X...^2/rpms.$$

The test for significance of treatment effects is the usual F-test of $T/E$ with $(p-1)$ and $(r-1)(p-1)$ degrees of freedom.

Estimates for the components of variance, $\sigma_s^2$, $\sigma_b^2$, and $\sigma_e^2$, are given by $S$, $\frac{(B-S)}{s}$, and $\frac{(E-B)}{ms}$, respectively. The estimated variance of a treatment comparison on a sample basis will be proportional to $E/rms$.

The estimate of the variance of a treatment comparison with $r'$ replicates, $m'$ composites, and $s'$ subsamples per composite is proportional to

$$\frac{S}{r'm's'} + \frac{(B-S)}{r'm's} + \frac{(E-B)}{r'ms}$$

which for computational purposes simplifies into

$$\frac{1}{r'}\left\{\frac{S}{m's'} + \frac{(B-S)}{m's} + \frac{(E-B)}{ms}\right\}. \qquad (4)$$

The reduction or the increase in the estimates of variance based on any combinations of $r'$, $m'$, and $s'$ may be computed provided that $S$, $\frac{(B-S)}{s}$, and $\frac{(E-B)}{ms}$ are accurate estimates of $\sigma_s^2$, $\sigma_b^2$, and $\sigma_e^2$, respectively. With the use of this statistical tool, the effect of the size of composite on the estimated variance among composites and on the estimated variance due to subsampling may be studied.

### SAMPLING PROCEDURE

The field experiment was made up of four replicates, each replicate consisting of five plots of 14 feet by 65 feet each (about one-fiftieth acre or eighty-two sq. m.). Corn was planted at the time of sampling. Each plot consisted of four rows with 18 hills to a row. The hills in a row were 3.5 feet (1.07 m.) apart. To simulate randomness, six sampling rows and 63 sampling sites to a row were considered for each plot. Two random numbers were drawn to locate a sampling unit. The first number was from 1 to 6 and the second was from 1 to 63. The sampling was confined to the elevated portions close to the row, and the depth of sampling was six inches.

The following sampling procedures were studied:

(1) Unrestricted random sample. Four random samples were taken from each plot and analyzed separately for percentage of moisture.

(2) Composite of size *4*. Two sets of four random borings were taken from each plot. Each set was made into a composite and two separate determinations were obtained from each composite.

(3) Composite of size *8*. Two sets of eight random borings were obtained from each plot. Each set was made into a composite and determinations were made as in (2).

(4) Composite of size *16*. Two sets of 16 borings were taken from each plot and made into composites separately. Determinations were made as in (2) and (3).

Each set of size 4, 8, and 16 borings was mixed thoroughly by hand in the field immediately after it was obtained. The composites were mixed in pails.

Each boring, in the case of the random sample, or each determination, in the case of composites, was placed in a weighed moisture can for moisture determination. The soil samples and cans were immediately weighed, oven-dried for 15 hours at 105°C., cooled for 30 minutes, and weighed again. The percentage of moisture of each sample was determined.

Analysis of variance was performed for each method of sampling. Analysis of variance (I) was employed for the data obtained from sampling procedure (1), and analysis of variance (II) for sampling procedures (2), (3), and (4).

### EXPERIMENTAL ANALYSIS AND RESULTS

Analyses of variance for the four methods of sampling for soil moisture are shown in tables 1, 2, 3, and 4, respectively. The effects of the size of the composite on the variance among composites and on the variance within composites are summarized in tables 5 and 6, respectively. A trend toward a decreasing variance may be noted in these two tables.

The estimated means for the different sizes of composites are shown in table 7. Very close agreement may be seen among the means obtained from sizes of composite 1, 4, 8, and 16.

Estimates of the variance of treatment comparisons with varying values of $r'$ replicates and $s'$ samples and with varying values of $r'$ replicates and $m'$ composites of different sizes to a plot when one or two subsamples ($s$) are taken were computed for this soil characteristic from their respective analyses of variance tables. The results are presented in tables 8, 9, 10, and 11.

The estimates given in table 8 were derived from the results given in table 1. From equation (2) the estimated variance of a treatment mean is

$$V(\bar{x}) = \frac{1}{r'}\left\{\frac{S}{s'} + \frac{(E-S)}{s}\right\}$$

where

$$\begin{aligned} S &= 1.2419 \\ E &= 2.6820 \\ s &= 4 \end{aligned}$$

are the values obtained from the analysis of variance of table 1. Thus, with this equation and the corresponding values for $S$, $E$, and $s$, the estimated variance was computed for any arrangement of $r'$ and $s'$. Values of the estimated variance were computed for $s' = 2$, 4, 6, 8, 10, 12, 14, 16, 18, 20 and $r' = 2$, 4, 6, 8, 10, 12. In general, if $r'$ and $s'$ are increased, the estimated variance decreases rapidly. Also, for a given $k = r's'$, increasing $r'$ will minimize the estimated variance.

Estimates of the variance of a treatment mean with varying values of $r'$ replicates, $m'$ composites, and $s'$ subsamples are shown in tables 9, 10, and 11 for sizes of composite 4, 8, and 16, respectively. These estimates were computed separately for each table from equation (4),

$$V(\bar{x}) = \frac{1}{r'}\left\{\frac{S}{m's'} + \frac{(B-S)}{m's} + \frac{(E-B)}{ms}\right\}.$$

For composite of size 4, the values of $S$, $B$, $E$, $s$, and $m$ were obtained from table 2. These values are $S = .0969$, $B = 1.1699$, $E = 6.4042$, $s = 2$, and $m = 2$. Thus, for composites of sizes 8 and 16, the corresponding values of $S$, $B$, $E$, $s$, and $m$ were obtained from tables 3 and 4, respectively. For each of tables 9, 10, and 11, estimates of the variance were computed for $r' = 2$, 4, 6, 8, 10; $m' = 1$, 2, 3, 4, 5, 6, 8, 10; and $s' = 1$, 2.

Examination of the results from the three sizes of composite indicates that within a given size of composite, very little gain in efficiency was obtained when duplicate determinations were made for fixed $r'$ and $m'$. For example, if $r' = 2$ and $m' = 1$ for size of com-

posite equal to 4, then from table 9, the estimated variance for $s' = 1$ is 0.9709 and for $s' = 2$, 0.9467. The reduction in variance as based on the variance for $s' = 2$ was only about three per cent. In general, the variance of treatment mean decreased as the size of composite increased for fixed $r'$, $m'$, and $s'$, or the larger size of composite was more efficient than smaller sizes for fixed $r'$, $m'$, and $s'$.

## DISCUSSION

The estimated means (table 7) between individual samples and composites of sizes 4, 8, and 16 showed very close agreement. It may be assumed that a composite value can be considered as an approximation of the mean of values of the contributing sampling units. The means were 18.32, 18.35, 18.42, and 18.23 per cent for sizes 1, 4, 8, and 16, respectively.

Let us now examine the estimated variances in table 5. Although the variance between composites decreased as the size of the composite increased, the rate of decrease was not large enough to indicate that the standard deviation of composite values can be considered as an approximation of the standard deviation of means of individual samples. As an example, let us look at the relationship

$$s^2 = s^2_{\bar{x}}(n)$$

where $s^2_{\bar{x}}$ is the estimated variance between composite values and $n$ is the number of borings composing each size of composite. The above sample relationship was obtained from the corresponding population value $\sigma^2_{\bar{x}} = \frac{\sigma^2}{n}$. From table 5 for $n = 16$, $s^2_{\bar{x}} = 0.2802$. With the above equation,

$$\begin{aligned} s^2 &= 0.2802 \ (16) \\ &= 4.4832. \end{aligned}$$

This value of $s^2$ is higher than the 1.2419 given in the same table for the unrestricted random sampling. Much higher approximations were obtained from composites of sizes 4 and 8.

One may evaluate indirectly the precision of some of the mean squares between composites ($s^2_{\bar{x}}$) for moisture. If $s^2 = 1.2419$ is assumed to be an accurate estimate of $\sigma^2$, then, for any given value of $s^2_{\bar{x}}$ the equivalent size of sample may be computed. Thus, for the composite of size 16,

$$s^2_{\bar{x}} = 0.2802,$$

which upon solving for $n$ in

$$\frac{s^2}{n} = 0.2802$$

gives

$$n = 4.4$$

where

$$s^2 = 1.2419.$$

From this point of view, a composite value from a composite of size 16 has a precision equivalent to the mean of a random sample of four single determinations. Similarly, for a composite of size 8, the composite value has a precision equivalent to the mean of a random sample of size 2. Evidently, these results imply that for moisture, single determinations must be taken from a composite of size greater than 8 to produce a precision equivalent to that of a mean of two determinations, each from a boring obtained at random.

Although a composite of, say, eight borings with one or two determinations does not provide as efficient an estimate of the soil characteristic studied as single determinations of eight individual borings, the loss in efficiency is rather small and the reduction in time and money required is large for most tests. Also, the evidence obtained does not indicate that the variation among determinations on sample within composites necessarily increases as the size of composite increases. Furthermore, this variation is small as compared to variation among composites. These results and considerations indicate that the most efficient sampling scheme for each plot is a composite containing as many individual borings as needed to obtain the precision desired. Very little increase in efficiency was obtained when two determinations, instead of one, were made for each composite. This would not be true if the mixing of the soil were inadequate or if the error due to determinations were large. More efficient estimates would generally be obtained if single determinations were made of two composites rather than duplicate determinations of a single composite. An important exception to this would be in cases where sufficient information on the magnitudes of soil sampling error is not available. Then two composites should be taken for each plot.

Even if only a single composite is selected at random from each plot, if the experiment is properly designed and conducted, unbiased estimates can be made of the experimental error. This estimate at least gives an upper bound of the sampling error.

To increase the efficiency of sampling, the sites for the individual borings which are to be composited should be selected in a systematic manner that tends to maximize the gain in efficiency from stratification.[2] Since the composite is considered as the s.u., it is not necessary to locate the individual borings at random to obtain an unbiased estimate of the sampling error. However, only those systematic schemes that give all locations in the population an equal chance of being selected are recommended. If there are $k$ possible composite samples for the systematic scheme, then one, or more if desired, should be selected at random to obtain unbiased estimates for each plot. Independent random selections should be made within each

[2] The efficiency of stratification relative to unrestricted random sampling for soil moisture is now being studied in the UP College of Agriculture and Central Experiment Station, Los Baños, Laguna.

plot. Another important advantage of a systematic scheme of selecting the individual borings is the time saved in the collection of samples.

The methods of soil sampling are being investigated at the UP College of Agriculture and Central Experiment Station in Laguna. These studies include the extension of the size of composite to 64 and the number of soil properties to more than four. Some cost functions will be included for each method of sampling used.

LITERATURE CITED

CLINE, M. G. 1944. Principles of soil sampling. Soil Sci. 58: 275–288.

————. 1945. Methods of collecting and preparing soil samples. Soil Sci. 59: 3–5.

COCHRAN, W. G., AND C. M. COX. 1950. Experimental designs. ix + 454 p. New York: John Wiley and Sons, Inc.

FISHER, R. A. 1951. The design of experiments. 6th ed., xv + 244 p., 5 fig. New York: Hafner Publishing Co.

JACOB, W. C., AND A. KLUTE. 1952. Sampling soils for physical and chemical properties. *Abstract in* Biometrics 8 (4): 386.

KEMPTHORNE, O. 1952. The design and analysis of experiments. xix + 631 p. New York: John Wiley and Sons, Inc.

MANN, H. B. 1949. Analysis and design of experiments. x + 198 p. New York: Dover Publications, Inc.

REED, J. F., AND J. A. RIGNEY. 1947. Soil sampling from fields of uniform and non-uniform appearance and soil type. Jour. Amer. Soc. Agron. 39: 26–40.

RIGNEY, J. A., AND J. F. REED. 1945. Some factors affecting the accuracy of soil sampling. Amer. Soil Sci. Proc. 10: 257–259.

YOUDEN, W. J., AND A. MEHLICH. 1937. Selections of efficient methods of soil samplings. Boyce Thompson Inst. Contrib. 9: 59–70.

TABLE 1

*Analysis of variance for unrestricted random sample*

| SV | DF | SS | MS |
|---|---|---|---|
| Reps | 3 | 129.5361 | 43.1787 |
| Treatments | 4 | 9.5184 | 2.3796 |
| R × T | 12 | 32.1844 | 2.6820 |
| Sampling error | 58 | 72.0324 | 1.2419 |
| Total [a] | 77 | 243.2713 | |

[a] Minus two d.f. for sampling error.

TABLE 2

*Analysis of variance for composite of size 4*

| SV | DF | SS | MS |
|---|---|---|---|
| Reps | 3 | 201.2838 | 67.0946 |
| Treatments | 4 | 46.4074 | 11.6018 |
| R × T | 12 | 76.8499 | 6.4042 |
| Composite w/in plot | 20 | 23.3973 | 1.1699 |
| Samples w/in composite | 38 | 3.6831 | 0.0969 |
| Total [a] | 77 | 351.6215 | |

[a] Minus two d.f. for samples w/in composite.

TABLE 3

*Analysis of variance for composite of size 8*

| SV | DF | SS | MS |
|---|---|---|---|
| Reps | 3 | 185.7383 | 61.9128 |
| Treatments | 4 | 15.8155 | 3.9539 |
| R × T | 12 | 39.8608 | 3.3217 |
| Composite w/in plot | 20 | 15.9133 | 0.7957 |
| Samples w/in composite | 39 | 3.8971 | 0.0999 |
| Total [a] | 78 | 261.2250 | |

[a] Minus one d.f. for samples w/in composite.

TABLE 4

*Analysis of variance for composite of size 16*

| SV | DF | SS | MS |
|---|---|---|---|
| Reps | 3 | 160.4794 | 53.4931 |
| Treatments | 4 | 11.7460 | 2.9365 |
| R × T | 12 | 20.8078 | 1.7340 |
| Composite w/in plot | 20 | 5.6050 | 0.2802 |
| Samples w/in composite | 40 | 2.4541 | 0.0614 |
| Total | 79 | 201.0923 | |

TABLE 5

*Size of composite and the estimated variance between composites*

| SIZE OF COMPOSITE | BETWEEN COMPOSITES MEAN SQUARE |
|---|---|
| 1 | 1.2419 |
| 4 | 1.1699 |
| 8 | 0.7957 |
| 16 | 0.2802 |

TABLE 6

*Size of composite and the estimated variance between samples within composites*

| SIZE OF COMPOSITE | BETWEEN SAMPLES MEAN SQUARE |
|---|---|
| 4 | 0.0969 |
| 8 | 0.0999 |
| 16 | 0.0614 |

TABLE 7

*Means of percentages of moisture of the different sizes of composites*

| TREATMENT | SIZE OF COMPOSITE | | | |
|---|---|---|---|---|
| | 1 | 4 | 8 | 16 |
| A | 18.15 | 18.02 | 18.36 | 18.17 |
| B | 18.20 | 17.85 | 17.87 | 17.66 |
| C | 18.82 | 18.19 | 18.49 | 18.38 |
| D | 17.84 | 17.83 | 18.19 | 18.09 |
| E | 18.59 | 19.85 | 19.21 | 18.83 |
| General mean | 18.32 | 18.35 | 18.42 | 18.23 |

TABLE 8

*Estimates of the variance of treatment mean with varying values of r′ replicates and s′ samples to a plot (from table 1)*

| NUMBER OF SAMPLES s′ | NUMBER OF REPLICATES r′ | | | | | |
|---|---|---|---|---|---|---|
| | 2 | 4 | 6 | 8 | 10 | 12 |
| 2 | .4905 | .2452 | .1635 | .1226 | .0981 | .0817 |
| 4 | .3352 | .1676 | .1117 | .0838 | .0670 | .0559 |
| 6 | .2835 | .1417 | .0945 | .0709 | .0567 | .0472 |
| 8 | .2576 | .1288 | .0859 | .0644 | .0515 | .0429 |
| 10 | .2421 | .1210 | .0807 | .0605 | .0484 | .0404 |
| 12 | .2317 | .1159 | .0772 | .0579 | .0464 | .0386 |
| 14 | .2244 | .1122 | .0748 | .0561 | .0449 | .0374 |
| 16 | .2188 | .1094 | .0729 | .0547 | .0438 | .0365 |
| 18 | .2145 | .1072 | .0715 | .0536 | .0429 | .0357 |
| 20 | .2110 | .1055 | .0704 | .0528 | .0422 | .0352 |

TABLE 9

*Estimates of the variance of treatment mean with varying values of r′ replicates and m′ composites (4) to a plot when one or two subsamples from each composite are taken*
*(from table 2)*

| NUMBER OF COMPOSITES m′ | NUMBER OF SUBSAMPLES s′ | NUMBER OF REPLICATES r′ | | | | |
|---|---|---|---|---|---|---|
| | | 2 | 4 | 6 | 8 | 10 |
| 1 | 1 | .9709 | .4854 | .3236 | .2428 | .1942 |
| | 2 | .9467 | .4733 | .3156 | .2368 | .1893 |
| 2 | 1 | .8126 | .4063 | .2709 | .2032 | .1625 |
| | 2 | .8005 | .4003 | .2668 | .2001 | .1601 |
| 3 | 1 | .7598 | .3799 | .2533 | .1900 | .1520 |
| | 2 | .7518 | .3759 | .2506 | .1879 | .1504 |
| 4 | 1 | .7335 | .3667 | .2445 | .1834 | .1467 |
| | 2 | .7275 | .3637 | .2424 | .1819 | .1455 |
| 5 | 1 | .7177 | .3587 | .2392 | .1794 | .1435 |
| | 2 | .7127 | .3563 | .2376 | .1782 | .1427 |
| 6 | 1 | .7071 | .3535 | .2357 | .1768 | .1414 |
| | 2 | .7030 | .3515 | .2343 | .1758 | .1406 |
| 8 | 1 | .6939 | .3469 | .2313 | .1735 | .1388 |
| | 2 | .6908 | .3454 | .2303 | .1728 | .1382 |
| 10 | 1 | .6859 | .3429 | .2286 | .1715 | .1372 |
| | 2 | .6835 | .3417 | .2278 | .1709 | .1368 |

TABLE 10

*Estimates of the variance of treatment mean with varying values of r' replicates and m' composites (8) to a plot when one or two subsamples from each composite are taken*
*(from table 3)*

| NUMBER OF COMPOSITES m' | NUMBER OF SUBSAMPLES s' | NUMBER OF REPLICATES r' | | | | |
|---|---|---|---|---|---|---|
| | | 2 | 4 | 6 | 8 | 10 |
| 1 | 1 | .5395 | .2697 | .1798 | .1349 | .1079 |
| | 2 | .5145 | .2572 | .1715 | .1286 | .1029 |
| 2 | 1 | .4275 | .2139 | .1425 | .1069 | .0855 |
| | 2 | .4151 | .2076 | .1384 | .1038 | .0830 |
| 3 | 1 | .3902 | .1951 | .1301 | .0975 | .0780 |
| | 2 | .3819 | .1909 | .1273 | .0955 | .0764 |
| 4 | 1 | .3717 | .1859 | .1239 | .0929 | .0743 |
| | 2 | .3654 | .1827 | .1218 | .0913 | .0731 |
| 5 | 1 | .3604 | .1802 | .1201 | .0901 | .0721 |
| | 2 | .3554 | .1777 | .1185 | .0888 | .0711 |
| 6 | 1 | .3529 | .1766 | .1176 | .0882 | .0706 |
| | 2 | .3488 | .1744 | .1163 | .0872 | .0698 |
| 8 | 1 | .3437 | .1719 | .1146 | .0859 | .0687 |
| | 2 | .3406 | .1703 | .1135 | .0851 | .0681 |
| 10 | 1 | .3380 | .1691 | .1127 | .0845 | .0676 |
| | 2 | .3356 | .1678 | .1119 | .0839 | .0671 |

TABLE 11

*Estimates of the variance of treatment mean with varying values of r′ replicates and m′ composites (16) to a plot when one or two subsamples from each composite are taken*
*(from table 4)*

| NUMBER OF COMPOSITES m′ | NUMBER OF SUBSAMPLES s′ | NUMBER OF REPLICATES r′ | | | | |
|---|---|---|---|---|---|---|
| | | 2 | 4 | 6 | 8 | 10 |
| 1 | 1 | .2691 | .1345 | .0897 | .0673 | .0538 |
| | 2 | .2517 | .1258 | .0839 | .0629 | .0503 |
| 2 | 1 | .2244 | .1122 | .0748 | .0561 | .0449 |
| | 2 | .2167 | .4084 | .0722 | .0542 | .0433 |
| 3 | 1 | .2101 | .1051 | .0700 | .0525 | .0420 |
| | 2 | .2050 | .1025 | .0683 | .0512 | .0410 |
| 4 | 1 | .2031 | .1015 | .0677 | .0508 | .0406 |
| | 2 | .1992 | .0996 | .0664 | .0498 | .0398 |
| 5 | 1 | .1987 | .0993 | .0662 | .0497 | .0397 |
| | 2 | .1957 | .0979 | .0652 | .0489 | .0391 |
| 6 | 1 | .1959 | .0979 | .0653 | .0489 | .0392 |
| | 2 | .1933 | .0967 | .0644 | .0483 | .0387 |
| 8 | 1 | .1932 | .0966 | .0644 | .0483 | .0386 |
| | 2 | .1904 | .0952 | .0635 | .0476 | .0381 |
| 10 | 1 | .1903 | .0952 | .0634 | .0476 | .0381 |
| | 2 | .1887 | .0943 | .0629 | .0472 | .0377 |

# BEHAVIOR OF SQUASH CHIMERAS [1]

J. M. CAPINPIN, V. D. RODRIGUEZ,[2] AND J. G. ODEJAR [3]

WITH TWO TEXT FIGURES

Two types of locally known squash chimeras propagated sexually and asexually gave four distinct phenotypic classes of fruits with regard to variegation or fruit banding. The leaves of type I had green lamina with yellow veins. Type II was characterized by exemplified green leaves with yellow middle veins occurring at random in a shoot. Marked similarities were observed between mother plants and the sexual and asexual progeny of both types, indicating that the mutation was probably germinal. The heredity of phenotypic classes of variegated fruits was in accordance with normal dihybrid segregation wherein two pairs of genetic factors are involved.

Pruning of the lateral and main branches of squash either before or after pollination tended to decrease the proportion of staminate to pistillate flowers, or to increase the number of the latter. The percentage of successful pollination was slightly higher for those plants whose tips were pruned before pollination. The pruning of terminal shoots of squash did not affect materially the abscission of flowers and fruits. Mechanical treatment increased the number of fruits formed.

Experiments on the behavior of two local types of squash chimeras when grown sexually and asexually may give us information as to whether these bud mutations occur in the somatic or in the germinal tissues of the plants. Hence, investigations were conducted in the garden lots of the Department of Agricultural Botany from July, 1948, to April, 1951, with the object of studying the heredity and variability of leaf and fruit variegations of squash chimeras and the effects of mechanical treatment on fruit setting, flower sex expression, and abscission.

## THE SQUASH CHIMERAS

The original plant of the chimeras under report was first observed by the senior author in his garden lot at Faculty Hill on November, 1941. This was a squash plant bearing variegated leaves, i.e., leaves with green lamina but with all the veins colored yellow. When vines of this variant were propagated by cuttings, the asexual progeny produced the same characteristics as the mother plant.

---

[1] Central Experiment Station Contribution No. 1724. Largely a combination of three papers: one entitled, "Genetic significance and economic importance of squash chimera," read by J. M. Capinpin before the Los Baños Biological Club, 1943; another entitled, "A study of genetic behavior of two types of squash chimera," presented by V. D. Rodriguez as graduation thesis, April, 1951; and a third entitled, "The effect of mechanical treatment on fruit setting and flower expression of squash chimera," presented by J. G. Odejar as graduation thesis, April, 1951. All investigations were conducted in the Department of Agricultural Botany under the direction of the senior author.

[2] Now with the Bureau of Soil Conservation.

[3] Now with the Bureau of Plant Industry.

Subsequent observations revealed that this bud variation was made up of two biotypes. One type (type I) was characterized by bearing branches and shoots which produced banded fruits which were pure yellow or had yellow portions. No full green fruits were formed on vines having variegated leaves. The second type (type II), in addition to producing full yellow and banded fruits from variegated branches, also produced some full green fruits. This appearance of green fruits from variegated shoots constitutes the main distinction between the two types of chimeras described in this paper.

## EXPERIMENTS

*Types of propagation.* Both asexual and sexual methods were used to propagate the two locally known types of squash chimeras. Young shoots selected at random were cut and planted in separate lots. The flowers of the asexually propagated chimeras representing genetic clones were self-pollinated and bagged. The seeds from these artificially self-pollinated plants were grown to maturity, and the resulting progeny were studied as to leaf variegation and fruit banding.

*Pruning.* Two forms of squash chimeras, namely, the Variegated and the Elongated Green form, were planted in two separate lots about four meters apart. Two of the six plants provided for each form were left untreated to serve as control. The next two plants were pruned before pollination, and the last two were pruned after pollination.

The first pistillate flowers appeared at approximately the third internode from the point of floral formation. The shoot was pruned carefully with a sharp knife to minimize disturbance to the flowers. Immediately after pruning, a tag bearing the date of pruning was tied to the stem near the flower stalk.

Pollination was done from six o'clock to eleven o'clock in the morning when the flowers were at the right stage of anthesis and dehiscence. Approximately twenty-four hours before the flowers opened, the pistillate and the staminate flowers were bagged. Artificial pollination was accomplished by gently rubbing together the stamens of the staminate flowers and the stigmas of the pistillate flowers. After pollination, the pistillate flowers were bagged again. Pertinent data were indicated on the tags which were tied around the stalks of the pollinated female flowers. Thereafter, the bagged flowers were frequently inspected to be sure that the bags gave adequate protection to the fertilized ovaries and to ascertain the periods of flower abscission.

## RESULTS AND DISCUSSION

### *Heredity and variability*

*Variegations of type I (mother plant) squash chimera.* Variegations of type I of the locally known squash chimeras were evidenced by the variegated leaves and banded fruits. The leaves were

green with all the veins colored yellow. The fruits were yellow with different patterns of banding. These banded fruits (fig. 1) may be conveniently divided into four types: (1) those with a broad green band in the middle leaving both ends yellow; (2) those colored yellow from the base to the middle and green from the middle to the tip; (3) those with one green band at the tip and another green band dividing the remaining yellow portion into two; and (4) those with green spots and/or green stripes.

Fig. 1.—Phenotypic segregates of fruit banding from squash chimera type I.

*Genetic behavior of the asexually and sexually propagated plants of type I squash chimeras.* Three plants grown sexually and three grown asexually from type I squash chimeras did not exhibit any distinct variation from the mother plants. All of the four types of fruits were represented in the fruits gathered from the six plants studied for chimeral mutation. Of the 220 fruits gathered, 106 belonged to the first group—yellow fruits with a green band at the middle; 53 to the second—fruits with yellow base and green tip; 44 to the third—yellow fruits with two green bands, one at the tip and a narrower one dividing the yellow portion into two; and 17 to the fourth—full yellow fruits with green spots and/or stripes. By chi-square test calculated on a normal dihybrid ratio of 9:3:3:1, wherein two factors might be involved in the segregation of this type of fruit

banding, a value of $P$ amounting to 90 to 72 per cent was obtained, indicating a fairly good fit (table 1).

While the individual plants belonging to type I squash chimera varied in the number of fruits formed, the weights of the fruits did not differ markedly (tables 2a, 2b, 2c, and 2d).

*Variegations of type II (mother plant) squash chimera.* The second type of squash chimera could be distinguished by the distribution of the yellow coloring of the veins. Green leaves with the middle veins colored yellow occurred on the shoots indiscriminately and at no definite intervals with full green leaves.

This type bore not only banded fruits but also full green fruits, a phenomenon not observed in type I. The fruits of this squash chimera (fig. 2) may be grouped into four: (1) phenotypic class 1—full green fruits; (2) phenotypic class 2—yellow fruits with a green band at the middle; (3) phenotypic class 3—fruits colored green three-fourths from the tip and yellow down to the base; and (4) phenotypic class 4—all yellow fruits spotted with green..

Fig. 2.—Phenotypic segregates of fruit banding from squash chimera type II.

*Genetic behavior of the asexually and sexually propagated plants of type II squash chimeras.* Three plants propagated asexually by cuttings and three propagated sexually from seeds of self-pollinated flowers were studied for the chimeral behavior. The same degree of variability exhibited by the different phenotypes produced from chimera type I was also noticed in the fruits of chimera type II (tables 4a, 4b, 4c, and 4d).

The plants of type II squash chimera propagated asexually and sexually did not show any deviation in leaf variegation from the mother plants. Green leaves with the middle veins colored yellow occurred on the shoots at no definite intervals with full green leaves.

All phenotypic classes of fruits were represented in the harvest. Of the 168 fruits gathered from six plants, 81 belonged to the first group, 36 to the second, 33 to the third, and 18 to the fourth. Chi-square treatment of these fruits on the basis of dihybrid ratio of 9:3:3:1 showed a probability of 89.14 per cent (table 3).

*Comparison of the progeny behavior of the two types of squash chimeras.* The results of this study seem to indicate that the fruit banding of both types of squash chimeras tended to follow the normal dihybrid Mendelian segregation 9:3:3:1 ratio. A higher probability, 91.26 per cent, was obtained in type I than in type II, which had 89.14 per cent. Both sexually and asexually propagated chimeras of the two types did not exhibit marked variations from the mother plants in leaf variegations and fruit banding.

The fruits gathered from plants of both types were markedly similar in banding. A difference was noted only in the phenotypic class 1 fruits, since the fruits of the first class of type I squash chimera were banded, whereas those of type II were all green. More fruits were gathered from plants belonging to the first class. The fruits of type I squash chimeras had a higher average weight than those of type II; the average weight of the fruits of type I was 837.78 grams and of those of type II, 804.99 grams.

As regards leaf variegations, both types exhibited the same characteristics as the mother plants.

A comparative study of the chi-square values of the asexually and sexually propagated plants of both types showed that the probabilities of sexually propagated plants of both types were higher than those of the asexually grown plants (table 5).

The behavior of both types indicates that the mutations of the squash chimeras were probably germinal rather than somatic.

*Effects of mechanical treatment on fruit setting and sex expression*

The plants of the Variegated form which received no particular treatment produced more flowers than the mechanically treated ones (table 6). On the other hand, plants of the Elongated Green form pruned after pollination produced a relatively larger number of flowers.

The sex ratio in both forms also varied according to the treatments (table 6). Pruning either before or after pollination decreased the proportion of staminate to pistillate flowers by as much as 41.7 per cent below that of the control. In other words, mechanical treatment tended to increase the number of female flowers over the number of male flowers.

The ability to produce staminate and pistillate flowers under ordinary conditions seems to be inherent in the variety itself. That the sex ratio can be shifted by environmental conditions has been proved by other workers. In this experiment, the number of pistillate flowers tended to increase and the number of staminate flowers to decrease when the squash plants were pruned before or after pollination.

Although there was no marked difference in average period of abscission between the control and any of the experimental plants, the tendency was for the pistillate flowers of the experimental plants of the Variegated form to fall off earlier than those of the control (table 7). For the Elongated Green form, mechanical treatment tended to lengthen the period of falling. The results seem to indicate that the length of the abscission period was more of a varietal characteristic rather than the effect of pruning before or after pollination. Cutting off the tips of the shoots or branches aided pollination and fruit setting (table 8).

TABLE 1

*Chi-square treatment of the fruits of plants from self-pollinated flowers of type I squash chimera*

(considered on the basis of two-factor Mendelian segregation)

| TYPE OF PROPAGATION | PLANT NUMBER | NUMBER OF FRUITS | YELLOW FRUITS WITH A BROAD GREEN BAND AT THE MIDDLE (Phenotype 1) | | FRUITS WITH YELLOW BASE AND GREEN TIP (Phenotype 2) | | YELLOW FRUITS WITH ONE GREEN BAND AT THE TIP AND A NARROWER ONE DIVIDING YELLOW PORTION INTO TWO (Phenotype 3) | | FULL YELLOW FRUITS WITH GREEN SPOTS AND/OR STRIPES (Phenotype 4) | | CHI-SQUARE |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | *observed* | *expected* | *observed* | *expected* | *observed* | *expected* | *observed* | *expected* | |
| Asexual | 1 | 40 | 19 | 22.50 | 10 | 7.50 | 9 | 7.50 | 2 | 2.50 | 1.785 |
| | 2 | 36 | 18 | 20.25 | 7 | 6.75 | 7 | 6.75 | 4 | 2.25 | 1.523 |
| | 3 | 32 | 15 | 18.00 | 9 | 6.00 | 5 | 6.00 | 3 | 2.00 | 2.667 |
| Sexual | 4 | 40 | 20 | 22.500 | 10 | 7.500 | 8 | 7.500 | 2 | 2.500 | 1.245 |
| | 5 | 38 | 18 | 21.375 | 8 | 7.125 | 7 | 7.125 | 5 | 2.375 | 1.003 |
| | 6 | 34 | 16 | 19.125 | 9 | 6.375 | 8 | 6.375 | 1 | 2.125 | 2.456 |
| | | 220 | 106 | | 53 | | 44 | | 17 | | 10.679 |

$P = 91.26$

TABLE 2a

*Weights of yellow fruits with a broad green band at the middle (phenotypic class 1) of type I squash chimeras*

| FRUIT NUMBER | WEIGHT OF FRUITS | | | | | |
|---|---|---|---|---|---|---|
| | Plant 1 | Plant 2 | Plant 3 | Plant 4 | Plant 5 | Plant 6 |
| | *grams* | *grams* | *grams* | *grams* | *grams* | *grams* |
| 1 | 900.5 | 981.0 | 898.3 | 903.6 | 875.6 | 950.8 |
| 2 | 878.0 | 963.5 | 792.4 | 926.3 | 905.5 | 890.7 |
| 3 | 894.7 | 952.3 | 943.2 | 915.4 | 856.6 | 895.6 |
| 4 | 906.1 | 898.3 | 930.6 | 914.6 | 925.7 | 789.0 |
| 5 | 918.2 | 893.6 | 865.6 | 878.3 | 860.5 | 913.6 |
| 6 | 916.3 | 962.0 | 856.3 | 803.4 | 853.7 | 902.8 |
| 7 | 885.6 | 878.8 | 843.8 | 812.6 | 980.1 | 732.6 |
| 8 | 895.7 | 898.7 | 836.9 | 872.5 | 762.8 | 699.8 |
| 9 | 876.8 | 879.5 | 795.0 | 720.3 | 873.5 | 733.7 |
| 10 | 972.5 | 903.8 | 798.3 | 886.2 | 857.4 | 906.5 |
| 11 | 983.0 | 916.5 | 908.1 | 897.0 | 906.5 | 900.1 |
| 12 | 973.3 | 970.0 | 875.3 | 732.0 | 893.4 | 902.6 |
| 13 | 896.9 | 873.5 | 858.4 | 756.6 | 752.6 | 783.4 |
| 14 | 752.3 | 875.3 | 892.0 | 925.7 | 870.8 | 893.6 |
| 15 | 785.1 | 751.4 | 976.3 | 870.1 | 883.7 | 737.7 |
| 16 | 856.3 | 800.5 | — | 700.8 | 872.4 | 782.6 |
| 17 | 712.5 | 870.0 | — | 850.9 | 896.3 | — |
| 18 | 710.0 | 750.0 | — | 951.6 | 850.6 | — |
| 19 | 750.0 | — | — | 982.4 | — | — |
| 20 | — | — | — | 916.5 | — | — |
| Total | 16,464.4 | 16,018.7 | 13,070.5 | 17,216.8 | 15,677.7 | 13,415.1 |
| Mean | 866.54 | 889.92 | 871.37 | 860.84 | 876.54 | 858.44 |

Average of the means = 876.4.

TABLE 2b

*Weights of fruits with yellow base and green tip (phenotypic class 2) of type I squash chimeras*

| FRUIT NUMBER | WEIGHT OF FRUITS | | | | | |
|---|---|---|---|---|---|---|
| | Plant 1 | Plant 2 | Plant 3 | Plant 4 | Plant 5 | Plant 6 |
| | *grams* | *grams* | *grams* | *grams* | *grams* | *grams* |
| 1 | 895.6 | 890.6 | 790.8 | 962.3 | 981.2 | 789.4 |
| 2 | 930.3 | 873.4 | 865.7 | 752.4 | 903.6 | 768.5 |
| 3 | 886.7 | 941.5 | 789.0 | 865.1 | 759.9 | 812.3 |
| 4 | 877.2 | 789.6 | 793.4 | 882.6 | 797.3 | 816.4 |
| 5 | 792.4 | 883.3 | 910.1 | 776.0 | 900.0 | 742.4 |
| 6 | 798.6 | 936.4 | 877.3 | 906.3 | 890.0 | 735.6 |
| 7 | 895.5 | 920.5 | 886.5 | 892.3 | 876.5 | 810.2 |
| 8 | 913.4 | — | 905.0 | 883.0 | 796.7 | 768.5 |
| 9 | 900.3 | — | 911.2 | 792.7 | — | 810.7 |
| | 894.6 | — | — | 876.5 | — | — |
| Total | 8,784.6 | 6,235.3 | 7,729.0 | 8,589.2 | 6,905.2 | 7,054.0 |
| Mean | 878.46 | 890.75 | 858.70 | 858.92 | 850.65 | 783.77 |

Average of the means = 853.54.

TABLE 2c

*Weights of yellow fruits with a green band at the tip and a narrower one dividing the yellow portion into two (phenotypic class 3) of type I squash chimeras*

| FRUIT NUMBER | WEIGHT OF FRUITS | | | | | |
|---|---|---|---|---|---|---|
| | Plant 1 | Plant 2 | Plant 3 | Plant 4 | Plant 5 | Plant 6 |
| | *grams* | *grams* | *grams* | *grams* | *grams* | *grams* |
| 1 | 900.8 | 756.2 | 875.2 | 872.6 | 790.8 | 890.0 |
| 2 | 792.3 | 780.4 | 816.5 | 868.5 | 788.2 | 751.3 |
| 3 | 868.4 | 765.3 | 718.2 | 852.7 | 715.7 | 765.6 |
| 4 | 853.4 | 832.4 | 902.0 | 796.2 | 896.3 | 798.7 |
| 5 | 742.3 | 716.5 | 801.6 | 755.7 | 900.5 | 856.4 |
| 6 | 816.4 | 900.0 | — | 900.0 | 901.2 | 916.3 |
| 7 | 832.5 | 912.0 | — | 872.6 | 892.4 | 852.3 |
| 8 | 753.7 | — | — | 760.5 | — | 836.4 |
| 9 | 736.2 | — | — | — | — | — |
| Total | 7,296.0 | 5,762.8 | 4,113.5 | 6,678.8 | 5,885.1 | 6,667.0 |
| Mean | 810.66 | 823.25 | 822.70 | 834.85 | 840.72 | 833.33 |

Average of the means = 827.58.

TABLE 2d

*Weights of full yellow fruits with green spots and/or stripes (phenotypic class 4) of type I squash chimeras*

| FRUIT NUMBER | WEIGHT OF FRUITS | | | | | |
|---|---|---|---|---|---|---|
| | Plant 1 | Plant 2 | Plant 3 | Plant 4 | Plant 5 | Plant 6 |
| | *grams* | *grams* | *grams* | *grams* | *grams* | *grams* |
| 1 | 798.2 | 876.4 | 709.3 | 801.5 | 842.6 | 790.1 |
| 2 | 776.3 | 856.3 | 718.8 | 786.4 | 863.7 | — |
| 3 | — | 862.5 | 721.6 | — | 856.2 | — |
| 4 | — | 786.7 | — | — | 798.6 | — |
| 5 | — | — | — | — | 786.4 | — |
| Mean | 1,574.5 | 3,381.9 | 2,149.7 | 1,587.9 | 4,147.5 | 790.1 |
| Total | 787.25 | 845.47 | 716.56 | 793.95 | 829.50 | 790.10 |

Average of the means = 793.63.

TABLE 3

*Chi-square treatment of the fruits of plants from self-pollinated flowers of type II squash chimera*

(considered on the basis of normal two-factor Mendelian segregation)

| TYPE OF PROPAGATION | PLANT NUMBER | NUMBER OF FRUITS | FULL GREEN FRUITS (Phenotype 1) | | YELLOW FRUITS WITH GREEN BAND AT THE MIDDLE (Phenotype 2) | | FRUITS COLORED GREEN THREE-FOURTHS FROM TIP AND YELLOW DOWN TO THE BASE (Phenotype 3) | | YELLOW FRUITS WITH GREEN SPOTS (Phenotype 4) | | CHI-SQUARE |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | *observed* | *expected* | *observed* | *expected* | *observed* | *expected* | *observed* | *expected* | |
| Asexual | 1 | 27 | 13 | 15.1875 | 6 | 5.0625 | 5 | 5.0625 | 3 | 1.6875 | 2.1371 |
| | 2 | 30 | 15 | 16.8750 | 5 | 5.6250 | 6 | 5.6250 | 4 | 1.8750 | 2.7540 |
| | 3 | 29 | 14 | 16.3125 | 6 | 5.4375 | 6 | 5.4375 | 3 | 1.8125 | 1.2184 |
| Sexual | 4 | 26 | 12 | 14.625 | 6 | 4.875 | 5 | 4.875 | 3 | 1.625 | 1.901 |
| | 5 | 28 | 13 | 15.806 | 7 | 5.269 | 6 | 5.269 | 2 | 1.756 | 1.075 |
| | 6 | 28 | 14 | 15.806 | 6 | 5.269 | 5 | 5.269 | 3 | 1.756 | 2.041 |
| | | 168 | 81 | | 36 | | 33 | | 18 | | 11.126 |

P = 89.14

TABLE 4a

*Weights of full green fruits (phenotypic class 1) of type II squash chimeras*

| FRUIT NUMBER | WEIGHT OF FRUITS | | | | | |
|---|---|---|---|---|---|---|
| | Plant 1 | Plant 2 | Plant 3 | Plant 4 | Plant 5 | Plant 6 |
| | *grams* | *grams* | *grams* | *grams* | *grams* | *grams* |
| 1 | 782.6 | 830.4 | 751.4 | 735.6 | 765.7 | 803.2 |
| 2 | 794.4 | 815.6 | 768.5 | 742.1 | 743.3 | 800.1 |
| 3 | 805.6 | 821.3 | 756.6 | 763.6 | 813.2 | 757.3 |
| 4 | 707.3 | 830.7 | 789.7 | 816.3 | 810.1 | 761.4 |
| 5 | 790.2 | 836.2 | 815.2 | 862.1 | 800.0 | 732.8 |
| 6 | 792.4 | 842.3 | 820.6 | 785.2 | 772.6 | 746.5 |
| 7 | 878.6 | 816.4 | 872.7 | 812.6 | 781.5 | 783.7 |
| 8 | 892.5 | 791.3 | 756.7 | 813.2 | 860.1 | 800.3 |
| 9 | 790.8 | 786.7 | 737.2 | 821.3 | 815.3 | 816.1 |
| 10 | 789.6 | 770.1 | 746.4 | 816.4 | 800.1 | 832.6 |
| 11 | 785.4 | 765.7 | 846.3 | 748.7 | 759.3 | 845.5 |
| 12 | 806.5 | 871.6 | 852.6 | 751.8 | 743.4 | 850.0 |
| 13 | 751.8 | 868.5 | 749.2 | — | 752.6 | 802.3 |
| 14 | — | 785.6 | 765.8 | — | — | 745.6 |
| 15 | — | 753.7 | — | — | — | — |
| Total | 10,367.7 | 12,186.1 | 11,028.9 | 9,369.0 | 10,217.2 | 11,077.4 |
| Mean | 797.51 | 812.4 | 787.70 | 780.75 | 785.93 | 791.23 |

Average of the means = 792.58.

TABLE 4b

*Weights of yellow fruits with green band at the middle (phenotypic class 2) of type II squash chimeras*

| FRUIT NUMBER | WEIGHT OF FRUITS | | | | | |
|---|---|---|---|---|---|---|
| | Plant 1 | Plant 2 | Plant 3 | Plant 4 | Plant 5 | Plant 6 |
| | *grams* | *grams* | *grams* | *grams* | *grams* | *grams* |
| 1 | 801.5 | 811.4 | 781.2 | 793.1 | 814.4 | 793.2 |
| 2 | 808.6 | 807.3 | 753.7 | 798.4 | 810.6 | 798.3 |
| 3 | 792.1 | 751.4 | 749.3 | 812.3 | 798.4 | 810.6 |
| 4 | 786.4 | 749.5 | 800.7 | 814.4 | 786.5 | 811.5 |
| 5 | 755.9 | 810.6 | 852.1 | 836.7 | 754.7 | 798.3 |
| 6 | 761.6 | — | 792.3 | 793.3 | 707.5 | 797.5 |
| 7 | — | — | — | — | 736.5 | — |
| Total | 4,706.1 | 3,930.2 | 4,729.3 | 4,848.2 | 5,408.6 | 4,809.4 |
| Mean | 784.35 | 786.04 | 788.21 | 808.03 | 772.65 | 801.56 |

Average of the means = 789.9.

TABLE 4c

*Weights of fruits colored green three-fourths from tip and yellow down to the base (phenotypic class 3) of type II squash chimeras*

| FRUIT NUMBER | WEIGHT OF FRUITS | | | | | |
|---|---|---|---|---|---|---|
| | Plant 1 | Plant 2 | Plant 3 | Plant 4 | Plant 5 | Plant 6 |
| | *grams* | *grams* | *grams* | *grams* | *grams* | *grams* |
| 1 | 812.1 | 857.8 | 799.5 | 789.2 | 809.7 | 816.3 |
| 2 | 815.6 | 865.7 | 787.1 | 795.4 | 806.5 | 812.7 |
| 3 | 788.2 | 789.4 | 842.5 | 798.6 | 798.5 | 792.6 |
| 4 | 794.5 | 776.5 | 816.3 | 813.5 | 797.3 | 798.1 |
| 5 | 796.1 | 789.3 | 810.4 | 803.4 | 816.2 | 789.4 |
| 6 | — | 849.2 | 795.6 | — | 795.4 | — |
| Total | 4,006.5 | 4,936.9 | 4,851.4 | 4,000.1 | 4,823.6 | 4,009.1 |
| Mean | 801.3 | 822.81 | 808.56 | 800.02 | 803.93 | 801.82 |

Average of the means = 806.4.

TABLE 4d

*Weights of yellow fruits with green spots (phenotypic class 4) of type II squash chimeras*

| FRUIT NUMBER | WEIGHT OF FRUITS | | | | | |
|---|---|---|---|---|---|---|
| | Plant 1 | Plant 2 | Plant 3 | Plant 4 | Plant 5 | Plant 6 |
| | *grams* | *grams* | *grams* | *grams* | *grams* | *grams* |
| 1 | 879.5 | 812.3 | 789.4 | 858.4 | 809.6 | 813.2 |
| 2 | 798.7 | 794.6 | 782.5 | 812.5 | 812.7 | 816.5 |
| 3 | 810.3 | 799.7 | 812.6 | 791.5 | — | 805.6 |
| 4 | — | 781.2 | — | — | — | — |
| Total | 2,488.5 | 3,187.8 | 2,393.5 | 2,462.4 | 1,622.3 | 2,434.7 |
| Mean | 829.5 | 796.95 | 797.83 | 820.8 | 811.15 | 811.56 |

Average of the means = 811.29.

TABLE 5

*Comparison of the chi-square treatments of the two types of squash chimeras propagated sexually and asexually* [a]

| TYPE | METHOD OF PROPAGATION | CHI-SQUARE | PROBABILITY |
|---|---|---|---|
| | | | *per cent* |
| I | Asexual | 5.975 | 74.23 |
| | Asexual | 4.704 | 85.68 |
| II | Sexual | 6.109 | 72.80 |
| | Sexual | 5.0172 | 82.99 |

[a] Data obtained from tables 1 and 3.

TABLE 6

*Flower counts for each treatment in two forms of squash*

| FACTOR | VARIEGATED | | | ELONGATED GREEN | | |
|---|---|---|---|---|---|---|
| | Control (No treatment) | Pruning before pollination | Pruning after pollination | Control (No treatment) | Pruning before pollination | Pruning after pollination |
| Number of male flowers ..... | 533 | 473 | 413 | 450 | 401 | 485 |
| Number of female flowers .... | 29 | 46 | 38 | 28 | 43 | 46 |
| Total number of flowers ..... | 562 | 519 | 451 | 478 | 444 | 531 |
| Percentage of male flowers ... | 94.7 | 91.2 | 91.6 | 94.2 | 95.5 | 91.4 |
| Percentage of female flowers .. | 5.3 | 8.8 | 8.4 | 5.8 | 9.5 | 8.6 |
| Sex ratio (male:female flowers) | 15.4:1 | 10.3:1 | 10.9:1 | 16.1:1 | 9.4:1 | 10.6:1 |

TABLE 7

*Average period of pistillate flower abscission in squash*

| TREATMENT | VARIEGATED | | | | ELONGATED GREEN | | | |
|---|---|---|---|---|---|---|---|---|
| | Number of flowers observed | Period of abscission | | | Number of flowers observed | Period of abscission | | |
| | | Lot 1 | Lot 2 | Average | | Lot 1 | Lot 2 | Average |
| | | *days* | *days* | *days* | | *days* | *days* | *days* |
| No treatment | 57 | 3.5 | 4.0 | 3.75 | 55 | 3.3 | 3.4 | 3.35 |
| Mechanical treatment of tips before pollination | 92 | 3.6 | 3.4 | 3.50 | 86 | 3.5 | 3.6 | 3.55 |
| Mechanical treatment of tips after pollination | 76 | 3.2 | 3.7 | 3.45 | 92 | 3.7 | 3.5 | 3.60 |

TABLE 8

*Number of pollinations and number of successful pollinations*

| TREATMENT | VARIEGATED | | | | | | ELONGATED GREEN | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Number of pollinations | | Number of successful pollinations | | Percentage of successful pollinations | | Number of pollinations | | Number of successful pollinations | | Percentage of successful pollinations | |
| | Lot 1 | Lot 2 | Lot 1 | Lot 2 | Lot 1 | Lot 2 | Lot 1 | Lot 2 | Lot 1 | Lot 2 | Lot 1 | Lot 2 |
| No treatment ..... | 25 | 22 | 6 | 7 | 24 | 23 | 14 | 22 | 4 | 6 | 29 | 28 |
| Mechanical treatment of tips before pollination . | 36 | 32 | 9 | 8 | 28 | 25 | 29 | 30 | 0 | 10 | 31 | 34 |
| Mechanical treatment of tips after pollination .. | 29 | 31 | 7 | 9 | 25 | 29 | 29 | 37 | 8 | 9 | 30 | 25 |

# EFFICIENCY OF AMMONIUM PHOSPHATE AND AMMONIUM SULFATE FERTILIZERS IN INCREASING THE FERTILITY OF LIPA CLAY LOAM SUBSOIL [1]

RUFINO L. SANTOS AND N. L. GALVEZ

Ammonium phosphate and ammonium sulfate fertilizers improved the fertility of Lipa clay loam as shown by the yields of grains and straw. The fertilizers were more efficient when applied to surface soil than to subsoil. The fertilized plots produced less empty grains. The nitrogen and phosphorus contents of both the grains and the straw responded positively to the kinds and rates of application of the nitrogenous fertilizers. The three rates of application of both ammonium sulfate and ammonium phosphate increased the nitrogen contents of the soils at tillering of the rice plants, but decreased them gradually until maturity.

Since lowland rice fields give higher yields than upland fields, the latter are usually converted to the lowland type of rice culture especially in places where there is enough water for irrigation. In regions where the source of water is not higher than the level of the upland fields, the surface layer, which is the fertile portion of the soil, is partly or completely removed with a bulldozer so that the lower horizon is left with a relatively low productivity level.

Previous work in the College of Agriculture at Los Baños, Laguna, has repeatedly shown that Lipa series respond significantly to the addition of nitrogenous fertilizers, but not of phosphatic or potash fertilizers.

Libatique (1931) found that moderate amounts of ammonium sulfate fertilizer tended to promote the growth and development of the roots of rice plants, as well as the formation and development of culms and leaves. Ammonium sulfate also increased the dry weight of the tops, but a heavy application of the fertilizer seemed to favor the development of the tops instead of the roots.

Espino and Estioko (1931) reported that nitrogen only, as nitrate or as ammonium, was inadequate for young rice plants, but that in a complete culture medium, nitrate and ammonium were beneficial to the young plants.

Macasaet (1936) found that the addition of mixtures of superphosphate and ammonium sulfate to tuff soils in pots of upland rice was either harmful or less beneficial than when ammonium sulfate was supplied alone. Furthermore, he noted that rice plants could grow normally in tuff soil without $K_2O$ when sulfate of ammonia was supplied.

---

[1] Central Experiment Station Contribution No. 1725. Thesis presented by the senior author for graduation with the degree of Bachelor of Science in Agriculture from the College of Agriculture, April, 1953. Prepared in the Department of Soils under the direction of the junior author.

Likewise, Cabotage (1941) found that a mixture of potassium sulfate and superphosphate did not materially improve the growth of rice plants; in some cases, the control was even better than the fertilized cultures. When to the two fertilizers was added ammonium sulfate, however, the response of the rice plants seemed very favorable, and the bigger the applications of ammonium sulfate the greater were the yield values obtained. Cabotage further noted that the improvement of the growth and yield of the plants seemed to be due to the ammonium sulfate rather than to the mixture used.

Almeda (1937) observed a marked increase in tillers and in ash content of tops as the amount of ammonium sulfate fertilizer was increased. He found that the best $N$-$P_2O_5$-$K_2O$ ratio for tuff soil in terms of dry weight and number of panicles was approximately 10-25-39.

According to Enrile (1938), Kelly found that potash and phosphoric acid were practically without effect upon the yield of rice, that complete fertilizer was not more effective than ammonium sulfate alone, and that the application of both ammonium sulfate and potassium sulfate produced an even lower yield than when ammonium sulfate alone was supplied to the plants.

Enrile (1938) did not see the advisability of adding potassium sulfate to ammonium sulfate. Ammonium sulfate fertilizer alone at the rate of 1½ tons to a hectare seemed sufficient to produce excellent growth and high yield of rice plants.

Mamañgon (1938) found that ammonium sulfate and diammonium phosphate fertilizers tended to cause upland rice to produce dark-green leaves. The best cultures of the ammonium sulfate series, obtained when 8.7 grams of ammonium sulfate, or 1½ tons to the hectare, were added to Lipa clay loam at the time of planting, were 44 per cent better than the best diammonium phosphate cultures which received 11.6 grams of diammonium phosphate, or 2 tons to the hectare, at the time of planting.

Espino and Crocker (1940) corroborated observations by Almeda (1937), Enrile (1938), and others that rice plants fertilized with varying amounts of ammonium sulfate were taller and more vigorous and had darker green leaves than the control. They also observed that the nitrogen content of the leaves of rice increased as the amount of ammonium sulfate was increased, but that the carbon content decreased, resulting in a low C/N ratio. The highest carbon-nitrogen ratio in the leaves was obtained from the control, or the unfertilized cultures.

Lusananda (1941), who also corroborated the observations of Almeda (1937), Enrile (1938), and Espino and Crocker (1940), found that in rice lots fertilized with ammonium sulfate the number of bearing culms was markedly greater than in the control and the grains ripened later than those of the control.

Madamba (1949) reported that separate applications of different amounts of ammophos and lime to Buenavista silt loam increased considerably the yield of straw and seeds of Dumali rice variety. The highest yield was from plants fertilized separately with 160 kilograms of ammophos and 6 tons of lime. For every ton of oven-dry straw produced, there was a corresponding harvest of 13 cavans of dry palay.

Whitney, Gardner, and Robertson (1950) obtained better results in the first year of test from manuring corn planted in subsoil exposed by leveling than from fertilizing it with commercial N and $P_2O_5$ at half the rates of these nutrients in the manure. However, in the second year of the test, commercial fertilizers made the yields of sugar beets and sugar superior to those produced on the residual manure plot. It was also in the second planting that manure increased the yield of corn three times, and those of sugar beets and sugar twice, as much as that of the control. The writers concluded that subsoils similar to the Fort Collins series may be rapidly brought back to nearly normal producing levels by either manure or commercial fertilizers.

Galvez and Bueno (1951) found that ammonium sulfate enhanced the vegetative growth of rice plants and significantly increased the yield over that of the control.

Samuels and Capo (1952) reported that when nitrogen was increased and $P_2O_5$ and $K_2O$ were held constant, there was an increase in the N content of sorghum, sugar cane, and coffee, but not in the $P_2O_5$ content. They further reported that when N and $K_2O$ were made constant, the percentage of $P_2O_5$ increased with increased applications of $P_2O_5$ to the three crops. There was a reduction in nitrogen concentrations when phosphorus was added to the sorghum for each increment of phosphate. With sugar cane, the decrease in nitrogen was realized only at the highest level of 300 pounds of $P_2O_5$ to an acre. With coffee, there was no definite trend.

Ammonium sulfate and ammonium phosphate fertilizers were added to Lipa clay loam subsoil in the Department of Soils of the College of Agriculture from December, 1951, to February, 1953, to determine the efficiency of these fertilizers in increasing the fertility of Lipa clay loam subsoil.

## MATERIALS AND METHODS

*Soil.* The Lipa clay loam used in this study was obtained from the Farm Crops Division of the Department of Agronomy. The land from which it was taken is generally level with fairly good drainage and has been continuously cultivated and cropped for several years. The surface soil is light brown, moderately compact, and easy to cultivate and has an average depth of 2.5 centimeters. Its water-holding capacity is 63.33 per cent; nitrogen content, 0.15 per cent; and pH-value, 6.28.

The subsoil is lighter in color than the surface and is even more compact. It pulverizes easily when dry, but is sticky and plastic when wet. Its water-holding capacity is 64.17 per cent; nitrogen content, 0.05 per cent; and pH-value, 6.50.

*Fertilizers.* The ammonium sulfate fertilizer, which was obtained from the Department of Agricultural Engineering, was gray in color and dissolved readily and completely in water. It contained 20.6 per cent nitrogen. The ammonium phosphate fertilizer was from the Fertilizer Administration and contained 16.0 per cent nitrogen and 16.0 per cent phosphoric acid. It also dissolved in water, but not as readily as ammonium sulfate.

*Rice seeds.* The rice seeds used in this study were from a non-lodging Thailand variety which matures in 119 days. This variety gives good yields in the lowland farms around the College where it is extensively used as a secondary rice crop. Although it has a relatively low milling percentage, it has a good eating quality.

*Pots.* The earthen pots used were cylindrical and had an average area of 680 square centimeters (0.068 sq. m.). They had an average height of 34.4 centimeters and an average upper inside diameter of 20.0 centimeters. They were painted inside with coal tar.

*Preparation of the cultures.* A sufficient amount of Lipa clay loam subsoil was collected, air-dried, pulverized, screened through a 10-millimeter sieve, mixed thoroughly, and then placed in 40 earthen pots at the rate of 20 kilograms to a pot. The pots were grouped into 10 lots of four replications each. The soil was made to simulate lowland rice soil.

On June 14, 1952, healthy and more or less uniform rice seeds, germinated between folds of moist filter paper, were planted directly in the pots at the rate of three seeds to a pot. Sixteen days later, the seedlings were thinned to one to a pot.

The fertilizers were applied on July 20, 1952, at the rates of 0.5, 0.6, and 0.8 gram of ammonium sulfate to a pot, which corresponded to 15, 20, and 25 kilograms of nitrogen to a hectare, respectively. The amounts of ammonium phosphate equivalent to these rates were 0.6, 0.8, and 1.06 grams to a pot, respectively. The different lots were fertilized at the following rates:

*Subsoil*

| | |
|---|---|
| I | No fertilizer, control |
| II | 0.5 gram ammonium sulfate |
| III | 0.6 gram ammonium sulfate |
| IV | 0.8 gram ammonium sulfate |
| V | 0.6 gram ammonium phosphate |
| VI | 0.8 gram ammonium phosphate |
| VII | 1.06 grams ammonium phosphate |

*Surface soil*

| | |
|---|---|
| VIII | No fertilizer |
| IX | 0.5 gram ammonium sulfate |
| X | 0.6 gram ammonium phosphate |

*Analyses.* The nitrogen and phosphorus contents of the harvests were determined in accordance with the method of the Association of Agricultural Chemists (1945). The soil was analyzed in a manner similar to the methods of Peech and English (1944).

## DISCUSSION OF OBSERVATIONS

There was no apparent difference in early growth among all the lots. Two weeks later, however, the tips of the leaves of the plants in the subsoil lots turned yellowish green and finally dried up, confirming the chemical analysis of the subsoil.

The effect of the fertilizer applied when the plants were 37 days old became very apparent 15 days afterwards. The plants in lots II, III, and IV, which were treated with 0.5, 0.6, and 0.8 gram of ammonium sulfate, respectively, were taller and darker and had broader leaves and more tillers than the plant in lot I. The growth in lots V, VI, and VII, which were treated with 0.6, 0.8, and 1.06 grams of ammonium phosphate, respectively, was also better than in lot I, but not as good as that in the ammonium sulfate series.

Lot VIII, surface soil which received no treatment, was better than lot I, but no better than lots II, III, IV, V, VI, and VII. This tends to show that the fertility of the subsoil was apparently restored to the level of the surface soil by the mere addition of ammonium sulfate and ammonium phosphate fertilizers. Lot IX, surface soil treated with 0.5 gram of ammonium sulfate, showed more luxuriant growth than lot X, also surface soil but treated with an equivalent amount of nitrogen from ammonium phosphate. This might indicate that nitrogen from ammonium sulfate is more readily absorbed by rice plants than that from ammonium phosphate.

The mean weights of the filled grains of lots I, II, and III (table 1) did not vary from each other, from which it may be inferred that 0.5- and 0.6-gram rates did not improve the fertility of the subsoil. The mean weight of the filled grains of lot IV was higher than that of lot I (control) and of lot II, which received 0.5 gram of ammonium sulfate, showing that of the three rates of nitrogen from ammonium sulfate, the 0.8-gram rate was the best.

In the ammonium phosphate series, lots V, VI, and VII, which gave identical yields, were each equal only to the control. Judged by the computed L.S.M.D. of 11.8 grams, the means of the lots treated with ammonium sulfate were just as good as those of the corresponding lots treated with ammonium phosphate. The highest rates of nitrogen application of the two fertilizers revealed that nitrogen from ammonium phosphate was only 4/5 times as efficient as that from ammonium sulfate in the subsoil lots. The surface-soil lots which separately received nitrogen from ammonium sulfate and ammonium phosphate gave identical yields of grains, showing that nitrogen from ammonium sulfate was as efficient as that from ammonium phosphate.

The mean weights of the straw of lots I and II were similar to each other (table 1). So were those of lots II and III and of lots

III and IV. Lot IV gave a yield of straw much higher than that of lot I.

In the ammonium phosphate series, lots V, VI, and VII gave results identical with each other and with the control. A comparison of the means of lots II and V and of lots III and VI showed no differences. On the other hand, lots IV and VII gave a difference of 15.1 grams in favor of the former. Lots IX and X, which gave identical results, gave higher yields of straw than lot VIII, which is surface soil alone.

The ratio of filled grain to straw (table 1) could hardly be used in determining the fertility level of the soils. It is apparent that the addition of nitrogenous fertilizers decreased the percentage of empty grains. The highest percentages of empty grains were found in the untreated lots.

The nitrogen from ammonium sulfate was more readily absorbed by rice plants than that from ammonium phosphate (table 2). The nitrogen from both sources enhanced the absorption of phosphorus. Their values were higher than those of the control.

The nitrogen contents of all the treatments decreased from tillering to maturity of the plants (table 3). The rate of application and the kind of fertilizer failed to influence the total decrement of nitrogen in the soil. The total decrement in the ammonium sulfate series was higher than that in the ammonium phosphate series.

Unlike nitrogen, the amounts of available phosphorus and potassium were not consistent from tillering to maturity (table 3). The first two rates of ammonium sulfate decreased the amount of available phosphorus from tillering to maturity, whereas the highest rate increased it. Ammonium phosphate decreased the available phosphorus from tillering to booting and then increased it until maturity.

The available potassium in the soil of lots II, V, VI, and X decreased from tillering to maturity; that in lot III increased from tillering to maturity. The potassium in lots I, IV, and VII increased from tillering to booting and then decreased until maturity; that in lots VIII and IX decreased from tillering to booting and increased from booting to maturity.

## LITERATURE CITED

A.O.A.C. 1945. Official and tentative methods of analysis of official agricultural chemists. 6th ed., xii + 932 p. Washington, D.C.: Assoc. of Agric. Chem.

Almeda, Virgilio T. 1937. Effects on dry matter and ash content of rice plants by varying the amounts of ammonium sulfate. Philippine Agriculturist **26**: 446–474.

Cabotage, Tomas G. 1941. Addition of potassium sulfate and superphosphate with ammonium sulfate to Lipa clay loam for upland rice. Philippine Agriculturist **30**: 136–144.

Enrile, Pablo C. 1938. Should potassium sulfate be added with ammonium sulfate to Lipa clay loam for upland rice? Philippine Agriculturist **27**: 148–167. *Fig. 1–7.*

ESPINO, R. B., AND R. P. ESTIOKO. 1931. A critical study of the nutritive values of nitrate nitrogen for young rice plants. Philippine Agriculturist 20: 27–42.

————, AND WILLIAM CROCKER. 1940. Effects upon the carbon-nitrogen ratio in leaves of rice grown in Lipa clay loam supplied with varying amounts of ammonium sulfate. Philippine Agriculturist 29: 34–47.

GALVEZ, N. L., AND PABLO M. BUENO. 1951. Residual effect of ammonium sulfate fertilizer with rice as indicator. Philippine Agriculturist 35: 75–82. *Fig. 1–3.*

LIBATIQUE, PABLO P. 1931. Comparative development of roots of rice plants grown in pots containing ammonium sulfate fertilizer of different amounts. Philippine Agriculturist 20: 121–137. *Pl. 1, fig. 1–2.*

LUSANANDA, BHAKDI. 1941. Effects of varying amounts of ammonium sulfate upon yield, rate of maturity, and size of grain of rice grown on Lipa clay loam. Philippine Agriculturist 30: 17–30.

MACASAET, MARIANO S. 1936. A study of the N-$P_2O_5$–$K_2O$ ratio for an upland rice grown in tuff soil in pots. Philippine Agriculturist 24: 678–699. *Fig. 1–5.*

MADAMBA, A. L., AND C. C. HERNANDEZ. 1949. The effects of ammo-phos and lime on the yield of upland rice (Dumali) grown on Buenavista silt loam. Jour. Soil Sci. Soc., Philippines 1: 204–209.

MAMAÑGON, MAGNO M. 1938. Comparative nutritive values of ammonium sulfate and diammonium phosphate for upland rice. Philippine Agriculturist 37: 363–375.

PEECH, M., AND L. ENGLISH. 1944. Rapid microchemical soil test. Soil Sci. 57: 676–686.

SAMUELS, GEORGE, AND BERNARDO G. CAPO. 1952. Effects of level of a fertilizer element on the uptake and concentration of that element and other elements in a plant. Agronomy Jour. 44: 352–357.

WHITNEY, ROBERT S., ROBERT GARDNER, AND D. W. ROBERTSON. 1950. The effectiveness of manure and commercial fertilizer in restoring the productivity of subsoils exposed by leveling. Agronomy Jour. 42: 239–245.

TABLE 1

*The mean weights of grains and straw*

| TREATMENT | FILLED GRAINS | OVEN-DRY WEIGHT OF STRAW | RATIO OF FILLED GRAINS TO STRAW | PERCENTAGE OF EMPTY GRAINS |
|---|---|---|---|---|
| | *grams* | *grams* | | |
| I. Control, subsoil alone | 11.7 | 17.2 | 0.68 | 23.93 |
| II. Subsoil plus 0.5 gram ammonium sulfate | 15.9 | 25.8 | 0.61 | 14.46 |
| III. Subsoil plus 0.6 gram ammonium sulfate | 19.9 | 30.9 | 0.64 | 13.56 |
| IV. Subsoil plus 0.8 gram ammonium sulfate | 28.1 | 39.5 | 0.71 | 11.74 |
| V. Subsoil plus 0.6 gram ammonium phosphate | 12.4 | 19.7 | 0.62 | 11.29 |
| VI. Subsoil plus 0.8 gram ammonium phosphate | 16.9 | 27.9 | 0.60 | 16.56 |
| VII. Subsoil plus 1.06 grams ammonium phosphate | 19.1 | 24.4 | 0.77 | 8.37 |
| VIII. Surface soil alone, no treatment | 13.1 | 24.7 | 0.53 | 25.19 |
| IX. Surface soil plus 0.5 gram ammonium sulfate | 31.4 | 51.8 | 0.60 | 21.01 |
| X. Surface soil plus 0.6 gram ammonium phosphate | 30.8 | 41.1 | 0.74 | 10.38 |
| Computed "F" | 3.40 | 6.37 | — | — |
| Probability | $P < 0.01$ | $P < 0.01$ | — | — |
| L.S.M.D. | 11.8 | 12.3 | — | — |

TABLE 2

*Mean amounts of nitrogen and phosphorus*

| TREATMENT | PERCENTAGE OF N IN | | PERCENTAGE OF $P_2O_5$ IN | |
|---|---|---|---|---|
| | Grain | Straw | Grain | Straw |
| I. Control, subsoil alone | 1.00 | 0.45 | 0.24 | 0.30 |
| II. Subsoil plus 0.5 gram ammonium sulfate | 1.09 | 0.47 | 0.51 | 0.45 |
| III. Subsoil plus 0.6 gram ammonium sulfate | 1.35 | 0.48 | 0.45 | 0.41 |
| IV. Subsoil plus 0.8 gram ammonium sulfate | 1.36 | 0.51 | 0.45 | 0.53 |
| V. Subsoil plus 0.6 gram ammonium phosphate | 0.96 | 0.43 | 0.49 | 0.50 |
| VI. Subsoil plus 0.8 gram ammonium phosphate | 1.16 | 0.45 | 0.62 | 0.50 |
| VII. Subsoil plus 1.06 grams ammonium phosphate | 1.09 | 0.53 | 0.57 | 0.48 |
| VIII. Surface soil alone, no treatment | 1.01 | 0.71 | 0.52 | 0.43 |
| IX. Surface soil plus 0.5 gram ammonium sulfate | 1.73 | 0.57 | 0.68 | 0.50 |
| X. Surface soil plus 0.6 gram ammonium phosphate | 1.49 | 0.36 | 0.56 | 0.52 |

TABLE 3

*Amounts of nitrogen, phosphorus, and potassium in soil at different stages of growth of the rice plant*

| TREATMENT | NITROGEN | | | PHOSPHORUS | | | POTASSIUM | | |
|---|---|---|---|---|---|---|---|---|---|
| | Tillering | Booting | Maturity | Tillering | Booting | Maturity | Tillering | Booting | Maturity |
| | *per cent* | *per cent* | *per cent* | *ppm.* | *ppm.* | *ppm.* | *ppm.* | *ppm.* | *ppm.* |
| I. Control, subsoil alone | 0.10 | 0.09 | 0.06 | 73.9 | 113.1 | 78.2 | 204.2 | 307.5 | 256.9 |
| II. Subsoil plus 0.5 gram ammonium sulfate | 0.15 | 0.11 | 0.08 | 139.3 | 83.9 | 56.4 | 237.1 | 228.2 | 222.0 |
| III. Subsoil plus 0.6 gram ammonium sulfate | 0.16 | 0.11 | 0.10 | 144.5 | 103.1 | 98.5 | 247.1 | 252.4 | 273.3 |
| IV. Subsoil plus 0.8 gram ammonium sulfate | 0.17 | 0.12 | 0.11 | 87.7 | 101.5 | 109.4 | 277.9 | 322.6 | 296.8 |
| V. Subsoil plus 0.6 gram ammonium phosphate | 0.13 | 0.11 | 0.08 | 132.5 | 83.4 | 136.2 | 300.6 | 288.7 | 284.2 |
| VI. Subsoil plus 0.8 gram ammonium phosphate | 0.12 | 0.11 | 0.09 | 102.2 | 78.7 | 156.6 | 277.2 | 261.9 | 253.8 |
| VII. Subsoil plus 1.06 grams ammonium phosphate | 0.11 | 0.11 | 0.08 | 114.7 | 66.3 | 186.0 | 278.4 | 290.6 | 285.5 |
| VIII. Surface soil alone, no treatment | 0.14 | 0.12 | 0.09 | 96.2 | 92.4 | 169.2 | 249.2 | 231.0 | 249.7 |
| IX. Surface soil plus 0.5 gram ammonium sulfate | 0.14 | 0.13 | 0.11 | 129.5 | 97.8 | 127.9 | 228.2 | 226.2 | 285.2 |
| X. Surface soil plus 0.6 gram ammonium phosphate | 0.14 | 0.12 | 0.11 | 149.4 | 89.7 | 138.6 | 293.3 | 271.5 | 266.5 |

# THE CONTROL OF THE MOST IMPORTANT COCONUT PESTS IN EASTERN INDONESIA [1]

TJOA TJIEN MO [2]

WITH ONE PLATE AND ONE TEXT FIGURE

Eastern Indonesia (fig. 1) is the richest copra area of the country. Before the second world war the yearly production was approximately 340,000 tons, with northern Sulawesi and the surrounding islands as the principal producers. After the war, the copra export from eastern Indonesia was recorded at 153,000 tons in 1947; 242,000 tons in 1948; 308,000 tons in 1949; 242,000 tons in 1950; 466,000 tons in 1951; and 287,000 tons in 1952.

As in other coconut-producing countries of the world, the coconut plantations in Indonesia are not free from diseases and pests. The diseases are practically of no importance, but the pests sometimes cause enormous damage. The coconut pests in eastern Indonesia generally differ from those which occur in the other parts of Indonesia. They are either epidemic or chronic in character.

The pests are usually hard to control because of various factors, such as (1) the inaccessibility of the plantations, (2) the shortage of labor for mechanical or chemical control on a large scale, and (3) the financial condition of the coconut tree owners. Thus, the government, whenever possible, has to maintain control measures over extensive areas at its own expense. The Institute for Plant Diseases and Pests at Bogor generally concentrates on the biological control of the various pests. If successful, such control measures always prove to be the least expensive. Unfortunately, the biological measures for the control of the various coconut pests in eastern Indonesia have not always been successful.

## BRONTISPA LONGISSIMA GESTRO VAR. SELEBENSIS GESTRO (HISPIDAE)

This insect (Pl. 1, fig. 1) was at one time the cause of great damage to the coconut trees in southern Sulawesi. The beetles and larvae affect the still folded young leaves which later do not open normally. The affected leaflets shrivel and wither. A severely affected tree loses its fruits and does not produce flowers any more. The trunk under the crown (Pl. I, fig. 2) becomes smaller, ¼ of the normal girth.

The *Brontispa* beetles apparently were present in southern Sulawesi and in the islands south of it before 1917. Probably they came

[1] Miscellaneous Contribution No. 27. From the Institute for Plant Diseases and Pests, Bogor, Indonesia.

[2] This article was prepared for delivery at the 8th Pacific Science Congress held in Diliman, Quezon City, Philippines, from November 16-29, 1953. Because of the author's illness, however, only the abstract of the article was read at the Congress by Mr. R. G. Sutardi Mangundojo.

Fig. 1.—Map of eastern Indonesia showing the areas of infestation and occurrence of the different coconut pests.

by way of the island of Salajar to the south of Sulawesi. In the next two years these insects multiplied and spread to such an extent that the copra production had declined considerably by 1919. From the mainland on the western arm of southern Sulawesi the insects quickly spread in the northern direction. In 1934 this part was already completely affected, as were also the eastern arm and surrounding islands. Copra production practically stopped because only 25 per cent of the living trees produced fruits, in considerably reduced quantities. To make matters worse, the weakened trees were also affected by *Aleurodiscus destructor* Mask., *Oryctes rhinoceros* L., and *Rhynchophorus ferrugineus* Oliv. so that 10 to 15 per cent were killed either by *Brontispa* only or by a combined attack of several pests.

According to Awibowo's investigation in 1929, the *Brontispa* eggs in southern Sulawesi were parasitized to ± 17 per cent only. The larvae and pupae did not have a single parasite, whereas those in Java were parasitized to the extent of ± 10 per cent and 60 to 90 per cent, respectively, by *Tetrastichodes brontispa* Ferr. (Pl. I, fig. 3). One pupa harbors a maximum of 35 parasites, or an average of 18 to 20.

*Brontispa* pupa parasites were shipped from Bogor. Up to 1935 a total of 27,500 parasitized *Brontispa* pupae was delivered to southern Sulawesi. The parasites were distributed in different locations and they were soon established. In some areas the parasitism reached ± 50 per cent.

In 1933 the results were not yet certain; however, in 1934 the results were definite. In 1935 infection by parasites in some places reached as high as 90 per cent. This encouraged the better organization of the breeding and distribution of parasites. In later years the breeding was done in southern Sulawesi itself. Through 1935 to 1941, inclusive, approximately 1,500,000 infected *Brontispa* pupae were distributed in the affected areas.

In 1937 it was observed that the coconut trees had recovered. They began to grow new green leaves and come into production again. But everywhere, especially towards the eastern and southern borders, the recent effects of the enormous devastation were still to be seen. Thousands of trees which had not died or been cut down had contraction of the upper part of the trunk.

The breeding and distribution of the *Tetrastichodes* parasites were stopped during the Japanese occupation, except on the island of Salajar. At the end of the war breeding and distribution were started again, but in 1948 they were stopped because it was observed that the natural equilibrium had already been established. The *Brontispa* pest appears to be definitely suppressed and southern Sulawesi returned to normal production once more.

### PROMECOTHECA CUMINGI BALY AND PROMECOTHECA SOROR MAULIK (HISPIDAE)

These insects (Pl. I, fig. 4a; Pl. I, fig. 4b) are miners. They cause the unfolded coconut pinnae to swell locally, like blisters caused by burn. In seriously affected leaves these blisters coalesce. In the end the leaves wither and the fruits drop. Seriously affected trees die.

*Promecotheca cumingi* occurs mainly in southern Sulawesi, and *P. soror,* in central and northern Sulawesi, Sula, Halmahera, and Moluccas. These beetles caused much damage in central Sulawesi from 1924 to 1925 and in 1927 and in southern Sulawesi from 1937 to 1939. The last time that they occurred in northern Sulawesi was in 1952, when ± 200,000 trees were affected. In the island of Halmahera damage was caused from 1935 to 1941, when at least 121,000 trees were badly injured.

Control measures could not be instituted except in southern Sulawesi and Halmahera. In southern Sulawesi biological control measures were tried by introducing the parasite *Pleurotropis parvulus* Ferr. (Pl. I. fig. 5) from Java into the affected area from 1937 to 1938. The trees recovered in 1939, but it was not established that this recovery was altogether the result of the introduction of the parasites.

In 1939, the same parasites were introduced three times into Halmahera, but the final results of the introduction were never studied although the parasites could still be found where they had been set free a year before.

### ALEURODISCUS DESTRUCTOR MASK. (ALEURODIDAE)

*Aleurodiscus destructor* (Pl. I, fig. 6) is another pest in southern Sulawesi that developed into harmful proportions in 1912, 1916, and 1918. In 1926 this pest was the cause of considerable anxiety because of the intensity of its infestation. The coconut leaves that harbor the insects turn yellow, the lower leaves hang limply down the trunks and afterwards wither, and nut production stops.

This whitefly occurred simultaneously with *Brontispa* so that it was not known at first which pest was primary and which was secondary. Van der Goot tried to control it by introducing the most important parasites, *Encarsia* sp. (Pl. I, fig. 7) and *Tetrastichus* sp. (Pl. I, fig. 8), from Java. The first shipment of parasites was sent to southern Sulawesi towards the end of 1927. The shipments were continued up to 1941. Although the parasites were already established in southern Sulawesi in 1928, the percentage of parasitic infestation always remained low. At one time it was 54 per cent.

The introduction of three predators, two *Scymnus* species and one *Ancylopteryx* species, could not control the whitefly, which had already destroyed thousands of coconut trees in conjunction with the previously mentioned *Brontispa, Oryctes rhinoceros* L., and *Rhynchophorus ferrugineus* Oliv.

Only after *Brontispa* had been controlled was the *Aleurodiscus* outbreak halted. From this it can be concluded that the *Brontispa* beetles were the primary pests. They weakened the coconut trees to such an extent that the whiteflies, which possibly were present in southern Sulawesi before 1918, were given the opportunity to multiply enormously. After the *Brontispa* pest had been controlled and the trees had recovered, the whiteflies were not capable of causing damage any more and they disappeared.

ASPIDIOTUS DESTRUCTOR RIGIDUS REYNE (COCCIDAE)

This coccid (Pl. I, fig. 9a) differs from the ordinary *Aspidiotus destructor* Sign. (Pl. I, fig. 9b) in that it produces fewer eggs, a maximum of 10 to 12 only, which can be seen in a half circle around the female. The ordinary *Aspidiotus destructor,* on the other hand, produces 40 to 60 eggs which are deposited around the female. The *rigidus* form can cause much damage; not only does it cause loss of fruit, but it also kills seriously affected trees.

In eastern Indonesia this scale insect has caused great damage several times. Its first appearance was reported in northern Sulawesi in 1918. Between 1925 and 1928 it caused a great deal of damage in the island of Sangir to the north of the Sulawesi. In 1929 it was reported in southern Sulawesi, and from 1934 to 1935, in the island of Bali. In 1937 this scale insect was again reported in northern Sulawesi; later on, in 1939, it was observed in Ambon. Between 1951 and 1953 it again caused much damage in northern Sulawesi.

The most disastrous outbreak was in the island of Sangir between 1925 and 1928. In May, 1925, only 10 trees were infested, but in October and November of that same year *Aspidiotus* had already affected some one hundred trees. By early 1926 the number of affected trees had already increased to 5000, and by September, 1926, to ± 30,000, of which several thousands died. At the end of 1927 the infestation had spread to 400,000 trees, of which ± 30,000 died. To control this dangerous scale insect, a number of parasites from Java were imported into Sangir, including *Comperiella unifasciata* Ish. (Pl. I, fig. 10) and beetles of the species *Chilocorus politus* Muls. (Pl. I, fig. 11). Although both insects became established on the island, they were incapable of suppressing the pest. The outbreak came to an end in 1928 when a great many of the insects were suddenly killed by some disease.

Another attempt was made to control the pest, which once more broke out in 1938 in northern Sulawesi, by importing the parasite *Comperiella unifasciata* into the affected area. Before the wasp could prove its efficiency, the outbreak was brought to a sudden stop by a disease.

Twice before the war, attempts were made to import the ladybird *Cryptognatha nodiceps* Msh. from Fiji to control *Aspidiotus,* but these proved futile because by the time the beetles arrived in Java they were already dead. In July, 1953, a third attempt failed

although the beetles were sent by airplane. The success of these ladybird beetles is doubtful because they might not adapt to the tougher *rigidus* form.

Attempts to control an outbreak of *Aspidiotus destructor rigidus* in Ambon (1939) by importing the predator *Chilocorus politus* and the parasite *Comperiella unifasciata* were never verified.

The only complete success was obtained in Bali, where *Aspidiotus* in 1938 was controlled with the imported enemies *Comperiella unifasciata* and *Chilocorus politus*. The parasite as well as the predator multiplied rapidly in their new country, and the pest was soon suppressed.

### SEXAVA NUBILA STAL., SEXAVA CORIACEA L., AND SEXAVA KARNYI LFS. (TETTIGONIDAE)

These three species of *Sexava* (Pl. I, fig. 14) have for many years been very harmful to the coconut trees in eastern Indonesia. The infestation by these three insects is chronic in character. The species *nubila* and *coriacea* occur in the islands to the north and to the east of the Sulawesi, whereas the species *karnyi* is found on the north coast of central Sulawesi and in the northern islands situated in the bay of Gorontalo.

The species *nubila* and *coriacea* appear practically everywhere in the eastern islands. *S. nubila,* however, nowhere causes as much damage as in the Talaud islands. Although these species were reported for the first time in 1916, damage must have been caused as early as 1890. The pest raged seriously in the years 1923, 1932, and 1949. The coconut trees did not bear any fruit for one to two years because the leaves were heavily damaged. In 1923 no copra at all was exported from the affected Talaud islands.

From the investigation by Leefmans in 1925 in Ambon where the *coriacea* species occurred, it appears that this species has two egg parasites, *Leefmansia bicolor* Wat. (Pl. I, fig. 15) and *Doirania leefmansi* Wat. (Pl. I, fig. 16). The most important parasite, *Leefmansia bicolor,* was introduced into the Talaud islands by Leefmans in 1925. Though these little wasps became established in several places, their multiplication and spread took place slowly; later on it appeared that the percentage of parasitizing remained less than 50 per cent.

The third *Sexava* species, *S. karnyi,* is much smaller than the two previously mentioned, but it is not less harmful. Its first appearance was reported in the Togean islands as early as 1910. The damage caused by this locust became worse and worse. In later years it was introduced into the mainland of northern Sulawesi, i.e., the northern coast opposite the infected group of the Togean islands. Other sources however report that the locusts have always been present on the mainland, although they had not attracted attention before. In 1952, ± 85,000 trees were damaged in an infested area of more than 40 hectares.

To control this *Sexava* species, *Leefmansia bicolor* parasites were imported in 1950 into the infested area, but apparently this experiment failed because in 1952 not a single parasite counld be found. A second attempt will be made. The *Sexava* problem in eastern Indonesia will remain a problem for the time being. The difficulties of control are by no means solved.

### DARNA CATENATUS SN. (LIMACODIDAE)

A pest in the Sulawesi which has not been controlled biologically is *Darna catenatus* Sn. (Pl. I, fig. 17). This is a small Limacodid which has caused more damage in the Palu valley (central Sulawesi) than many another larger insect. At times it can be so harmful that the coconut leaves turn brown and the production stops for one to two years.

According to the old inhabitants, the *Darna* caterpillar was already present in the Palu valley before 1900. The pest raged now and then and disappeared by itself. Later on the pest became chronic in the northern part of the valley where the yearly rainfall is less than 1000 mm. In the southern part where the yearly rainfall is in excess of 1000 mm. and likewise in other parts of the Sulawesi, it rarely occurred. Since 1950, however, the *Darna* caterpillar has become established in the southern part of the Palu valley, and the pest is now chronic throughout the valley.

For lack of a better method, control was based on cutting off methodically the infested leaves, except the three youngest leaves and the tip. The whole valley was divided into sections, and two sections daily were examined by two specially trained investigators. In this manner any center of infestation became known early. The pest generally started in trees in isolated places or in groups of trees situated in paddy fields, *ladangs*, etc.

Control by cutting off the infested leaves was used for the first time in 1938. In that year 15,600 trees had to be pruned, and in the next year, only 1930 trees. After that the situation was well in hand. In 1941 only 350 trees needed pruning. Later the pest could be checked at the beginning of infestation. During the Japanese occupation, from 1942 to 1945 inclusive, the control of the pest became difficult since the government forbade the burning of the chopped-off leaves. Because of this restriction, more trees became infested and more trees needed pruning—1330 trees in 1944 and 1680 trees in 1945. At the end of the war proper control measures were again possible, but because of changes in outlook and other circumstances, they could not be resumed before 1947. In the meantime the pest again spread over the valley.

According to reports of observation officials, control is now obtained by spraying with DDT. Thus, the *Darna* caterpillar has been kept under control by mechanical or chemical means. Biological control, however, will always be kept in mind.

BIBLIOGRAPHY

AWIBOWO, R. 1934–35. De klapperbladkever *Brontispa fraggati* var. *selebensis* en zijn biologische bestrijding op Celebes. Landbouw. **10**: 76–92.

FRANSSEN, C. J. H., EN TJOA TJIEN MO. 1952. Biologische bestrijding van de klapperplagen op Zuid Celebes. Landbouw. **24**: 319–360.

KALSHOVEN, L. G. E., J. VAN DER VECHT, H. J. V SODY, EN A. C. V. VAN BEMMEL. 1950–1951. De plagen van de Cultuurgewassen in Indonesie. Dl. I en II.

LEEFMANS, S. 1927. Gegevens over sabelsprinkhanen als cocosvijanden in N. I. en hunne parasieten. Med. v. h. Institutt voor Plantenziekten, No. 72.

————. 1927. A new species from the Island Poat (Celebes). Troubia 9: 411–412.

PONTO, S. A. S., EN TJOA TJIEN MO. 1950. De bestrijding van een slakrups, *Darna* (*Orthocraspeda*) *catenatus* (Sn.), op klapper in het Palu-dal. Landbouv. 22: 69–81.

REYNE, A. 1929. Over een hevige schildluisplaag in de cocospalmen op het eiland Groot-Sangihe. Vakblad voor Biologen **10**: 129–132.

————. 1945. Notes on the biology of *Comperiella unifasciata* Ishii and its host *Aspidiotus destructor rigidus* nov. subsp. Tijdschrift voor Entomologie. Feestbundel. 88e Dl. 1945: 294–302.

————. 1946. Studies on a serious outbreak of *Aspidiotus destructor rigidus* in the coconut-palms of Sangi (North Celebes). Tijdschrift voor Entomologie. Dl. 89 (1948): 83–123.

————. 1948. De cocospalm. De Landbouw in de Indische Archipel, uitgegeven onder Redactie van C. J. J. van Hall en C. van de Koppel. D1 IIA. 1948: 427–527.

TAMMES, P. M. L. 1947. De bevolkingscultuur van klapper, in het bijzonder in Oost-Indonesie. Med. v. h. Departement van Economische Zaken in N. I. No. 11.

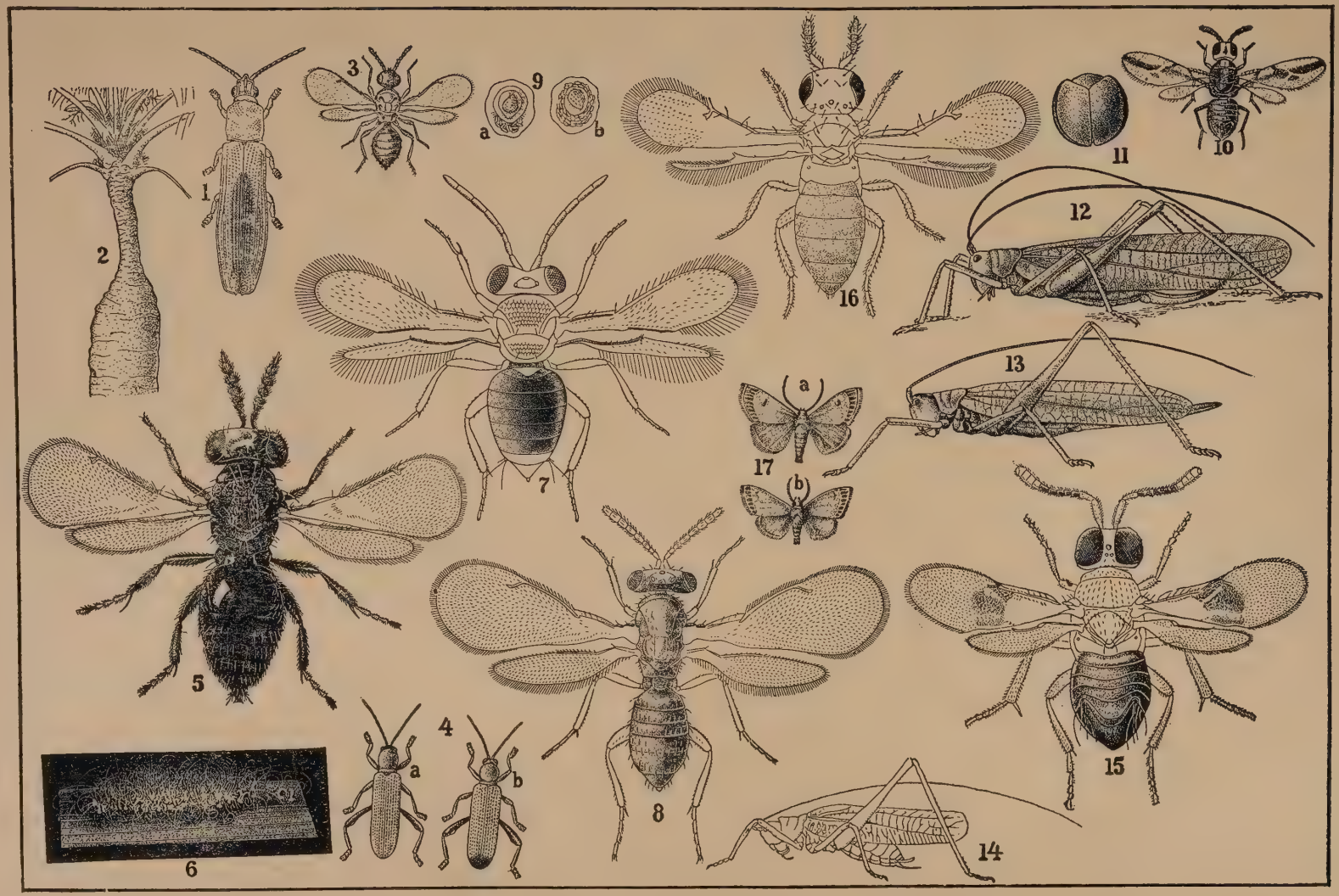
TAYLOR, T. H. C. 1935. The campaign against *Aspidiotus destructor* Sign. in Fiji. Bull. of Ent. Res. **26**: 1–102.

————. 1937. The biological control of an insect in Fiji. London.

TJOA TJIEN MO. 1953. Memberantas hama-hama kelapa dan kopra. Warta bulanan Kantor Pusat Statistiek. Export Indonesia Timur 1948–1952.

PLATE I

Fig. 1. *Brontispa longissima* var. *selebensis*. 3.5×.
" 2. A constricted coconut tree as a result of the attack of *Brontispa longissima* var. *selebensis*.
" 3. *Tetrastichodes brontispae* (after Awibowo, 1934/1935). 7.5×.
" 4. a. *Promecotheca cumingi*, 2×; b. *Promecotheca soror*, 2×.
" 5. *Pleurotropis parvulus* (after Taylor, 1937). 31.5×.
" 6. *Aleurodiscus destructor*. 0.5×.
" 7. *Encarsia* sp. (after Franssen/Tjoa, 1952). 60×.
" 8. *Tetrastichus* sp. (after Franssen/Tjoa, 1952). 30×.
" 9. a. *Aspidiotus destructor rigidus*, 5×; b. *Aspidiotus destructor*, 5×.
" 10. *Comperiella unifasciata* (after Kalshoven, 1951). 10×.
" 11. *Chilocorus politus*. 2×.
" 12. *Sexava nubila*. 0.5×.
" 13. *Sexava coriacea*. 0.5×.
" 14. *Sexava karnyi* (after Leefmans, 1927). 0.5×.
" 15. *Leefmansia bicolor* (after Leefmans, 1927). 20×.
" 16. *Doirania leefmansi* (after Leefmans, 1927). 45×.
" 17. *Darna catenatus;* a. female, b. male. 1×.




TJOA TJIEN MO: MOST IMPORTANT COCONUT PESTS IN EASTERN INDONESIA

# CLEFT-GRAFTING LANZONES, LANSIUM DOMESTICUM [1]

SERGIO T. DE LA CRUZ AND LEON G. GONZALEZ

WITH ONE TEXT FIGURE

One-year-old and two-year-old lanzones seedlings were used in a grafting test employing three methods of preparing the scions and three covering materials. Among the year-old seedlings, the average percentage of success one month after grafting was 46.7 per cent, and three months after grafting, 18.9 per cent. Among the two-year-old stocks, the average percentage of success was 25.5 per cent one month after grafting and 20.6 per cent three months after grafting.

Treatment of the scion with 1000 ppm. indoleacetic acid proved detrimental to the union of stock and scion. Banana petiole was found to be the best covering material, for it did not need watering like the sawdust and was not costly like the test tube.

In spite of the economic importance of lanzones, *Lansium domesticum* Correa, little has been done to perpetuate its superior seedling varieties through asexual propagation. Lanzones responds readily to inarching and marcotting, but these methods are not rapid enough to supply the demand for planting materials. Cleft-grafting would be a more promising method if its percentage of success could be raised to more than the usual 30 per cent.

According to Mendiola (1922) lanzones is not easily propagated by shield budding. He mentioned further that attempts to graft lanzones on santol seedlings were unsuccessful.

Polo (1920) obtained very discouraging results from growing lanzones from stem cuttings. In his marcotting experiments, there was marked hastening of root formation when weak concentrations of potassium permanganate were applied on the junctions before they were covered with soil.

Gonzalez (1934) reported that he was more successful in cleft-grafting lanzones when vigorous two- to three-year-old seedlings were used as stocks. Shield budding gave a low percentage of union, and bark grafting five- to ten-year-old seedlings gave too low a percentage of success to be of practical value.

According to Went and Thimann (1937), Snow, in 1935, found excellent activation of cambial growth after applying auxin *a* and indole-3-acetic acid to grafted *Helianthus* and *Pisum* seedlings. They mentioned further that Soding, in 1936, showed that insertion of crystals of indoleacetic acid into the cambium of woody twigs gave rise to a rapid growth of new secondary wood. The effect, which was

[1] Central Experiment Station Contribution No. 1726. Thesis presented by the senior author for graduation with the degree of Bachelor of Science in Agriculture from the College of Agriculture, October, 1953. Prepared in the Department of Agronomy under the direction of the junior author.

due entirely to cambium activation, was reported visible down to about three centimeters below the point of application.

This study was undertaken in the Department of Agronomy from May, 1952, to September, 1953, to determine the influence of (a) age of stock on the percentage of union in cleft-grafting, (b) three methods of preparing scions, and (c) three covering materials.

## MATERIALS AND METHODS

*Transplanting and preparation of stocks.* One hundred eighty each of one- and two-year-old lanzones seedlings of uniform size and vigor were transplanted with care in earthen pots of 9.5 × 8.5 inches containing ordinary top soil. The newly transplanted seedlings were grouped together according to age and placed under partial shade in the nursery. The plants were watered whenever necessary. They were given ordinary care until fully established, as indicated by the new growths that appeared on the terminal portions of the plants. The seedlings were then considered ready for grafting.

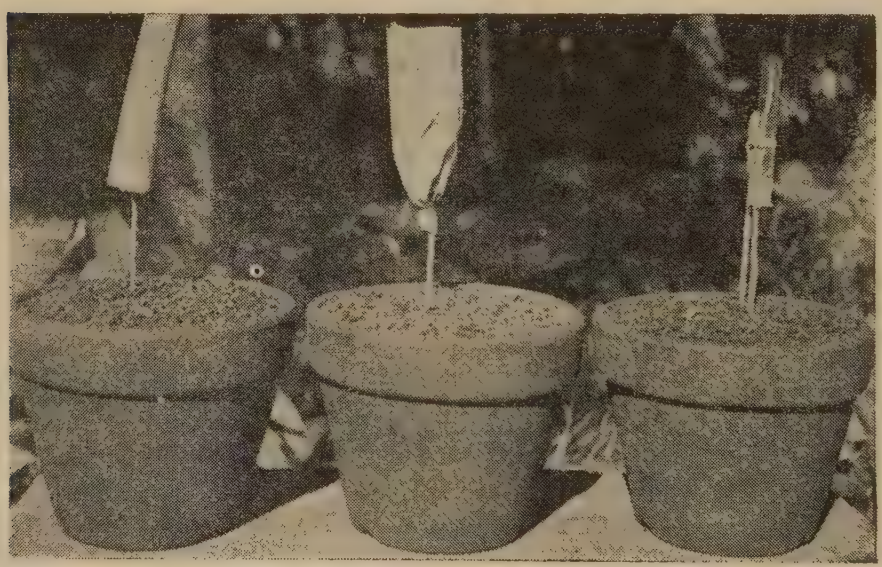


Fig. 1.—The different materials used to cover the scions after grafting: left, banana petiole; center, Manila paper with sawdust; right, test tube. (*Photographed by the Photographic Division of the College of Agriculture*).

*Selection and preparation of scions.* While the transplanted stocks were getting established, scions were selected from among the terminal branches of two sweet, bearing lanzones trees in the College orchard. The scions selected had terminal unopened buds which were free from physical imperfections. These scions were mostly terminal growths.

Prior to grafting, the scions were prepared in various ways: (a) selected terminal branches were defoliated but left uncut for a period of one month, (b) leafy scions were cut at once, and (c) leafy scions were treated with indoleacetic acid at a concentration of 1,000 ppm.

The scions for the undefoliated treatment were grafted at once after being cut from the trees. All the scions used were cut to a consistent length of 14 centimeters.

*Grafting.* Grafting was done when new growths had formed on the stocks, showing that they were sufficiently established. The scions were severed from the trees, matched to stocks that were similar in diameter, and cleft-grafted about fifteen centimeters above the ground. The top portion of the stock was cut squarely, and a longitudinal slit was made at the center of the remaining portion by gradually running the sharp edge of the knife downward to a length of two centimeters. Then incisions were made on opposite sides of the scion to form a cleft similar in length to the cut on the stock. The incised scion was then inserted into the stock in such a way that the cambial regions fitted closely. The scion and stock were tied tightly with grafting tape starting from below. The wrapping was done such that the tape extended a few centimeters below and above the grafted portion. The graft was then covered with banana petiole, with sawdust, or with a test tube (fig. 1). The successful grafts were observed three weeks after grafting.

## RESULTS AND DISCUSSION

*Influence of treatment of scions.* There is no consistent practice among plant propagators as to the preparation of scions for cleft-grafting. Following Wester's method (Popenoe, 1920), some advocate the use of previously defoliated branches as scions, whereas others claim that undefoliated scions are just as good. Snow (1935) found excellent activation of cambial growth in grafted *Helianthus* and *Pisum* seedlings after the application of indole-3-acetic acid.

To test these points, a total of 360 grafts was prepared. Sixty each of the defoliated scions, the undefoliated scions, and those dipped in indoleacetic acid (1,000 ppm.) were used for each age of the stocks. The results showed that with the one-year-old stocks, regardless of the covering used, the defoliated scions consistently gave a greater number of living grafts than either the undefoliated scions or the indoleacetic acid-treated ones. Among the plants grafted, the percentage of living grafts after the one-month observation period was from 50 to 85 per cent for the defoliated scions; 50 to 65 per cent for the undefoliated scions; and from 5 to 20 per cent only for the hormone-treated scions. The defoliated scions were no better than the undefoliated ones. The results from the hormone-treated scions did not come out as expected, possibly because the strong concentration of the hormone used adversely affected the cambium layers of

both scions and stocks. It would be worthwhile to try other concentrations in future studies.

*Influence of covering materials.* Since the hormone-treated scions gave a very low percentage of success, only the influence of the covering materials on the defoliated and undefoliated treatments will be discussed. With the one-year-old stocks, the test tube was as good as the banana petiole, but with the two-year-old stocks, the test tube and sawdust coverings gave slightly higher percentages of success to the defoliated and undefoliated scions, respectively (table 1).

Some propagators consider the use of banana petioles more practical since they are readily available, are very easy to prepare, and do not need frequent watering. They have also been found very suitable in the open field. On the other hand, test tubes have been found to be very expensive and are mostly used when the grafted plants are kept in a shady place. The objection to sawdust is that it needs frequent watering.

*Influence of age of stocks.* Except when grafted with the hormone-treated scions, the one-year-old stocks gave a higher percentage of success than the two-year-old stocks during the one-month period of observation. The highest percentage of successful grafts for the one-year-old stocks was 85; their average percentage in all treatments was 46.7. The two-year-old stocks gave 50 as their highest percentage, with an average in all treatments of 25.5 per cent.

It was easier to find scions that matched the stem diameters of the one-year-old stocks than those of the two-year-old stocks, which were about twice as big. Quite often the scions for the two-year-old stocks had to be cut at the hard woody portion so that they would be about the size of the stocks. Cutting them at this region renders them not very suitable for grafting. This seems to be the explanation for the low percentage of union when older stocks are used.

Another disadvantage of using two-year-old stocks is the added expense of maintaining them for one year longer.

*Infection of living grafts.* Long after the customary period of observation was over, when new buds had begun to develop on the grafts and the union between the stocks and the scions had been declared successful, some of the grafts began to show signs of failure. The young leaves formed since grafting began to wilt and in about three weeks, despite good care, the infected plants died completely. Thus, three months after insertion, the 84 grafts on the one-year-old stocks considered living one month after grafting were reduced by an unidentified disease to 33, a reduction of 60.7 per cent. Likewise, among the two-year-old stocks, the 46 grafts living at one month were reduced to 37 after the three-month period, a reduction of 19.5 per cent.

LITERATURE CITED

GONZALEZ, L. G. 1934. Outstanding results of agronomic and horticultural research. Philippine Agriculturist 23: 380–405.

MENDIOLA, N. B. 1922. Improvement of the lanzon. Philippine Agriculturist 11: 117–124.

POLO, O. C. 1920. Propagation of lanzones by marcotting and by cutting. Philippine Agriculturist 14: 142–150.

POPENOE, W. 1920. Manual of tropical and subtropical fruits. New York: The MacMillan Co.

ROBERTS, R. H. 1949. Theoretical aspects of graftage. Bot. Rev. 15: 423–463.

WENT, F. W., AND K. V. THIMANN. 1937. Phytohormones. 5th ed., xi + 249 p. New York: MacMillan Co.

TABLE 1

*Successful grafts of one- and two-year-old lanzones seedlings as influenced by different methods of preparing scions and different covering materials*

| TREATMENT | NUMBER OF PLANTS GRAFTED | NUMBER OF SUCCESSFUL GRAFTS ON | | | |
|---|---|---|---|---|---|
| | | One-year-old stocks | | Two-year-old stocks | |
| | | After one month | After three months | After one month | After three months |
| Defoliated scions: | | | | | |
| Covered with | | | | | |
| Banana petiole | 20 | 17 | 4 | 4 | 4 |
| Sawdust | 20 | 10 | 2 | 8 | 8 |
| Test tube | 20 | 17 | 1 | 5 | 5 |
| Undefoliated scions: | | | | | |
| Covered with | | | | | |
| Banana petiole | 20 | 11 | 9 | 6 | 3 |
| Sawdust | 20 | 10 | 8 | 6 | 4 |
| Test tube | 20 | 13 | 6 | 10 | 7 |
| Hormone-treated (not defoliated) scions: | | | | | |
| Covered with | | | | | |
| Banana petiole | 20 | 1 | 1 | 1 | 1 |
| Sawdust | 20 | 1 | 1 | 2 | 2 |
| Test tube | 20 | 4 | 1 | 4 | 3 |
| Total | 180 | 84 | 33 | 46 | 37 |
| Percentage of success | | 46.7 | 18.9 | 25.5 | 20.6 |

# POLLINATION OF VANILLA FLOWERS BY HAND [1]

PEDRO A. DAVID

WITH FIVE TEXT FIGURES

The flowering season of the vanilla plants in the College of Agriculture at Los Baños, Laguna, begins as early as March and lasts till June.

Natural fertilization seldom occurs in vanilla because of the peculiar arrangement of its flower structure (fig. 1). The anther

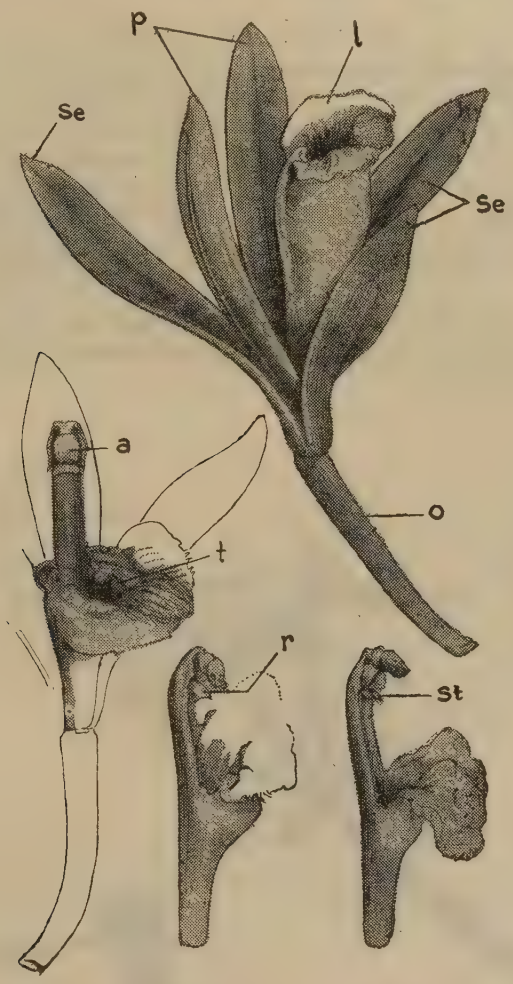



Fig. 1.—Essential parts of vanilla flower: *a*, the pollen-bearing anther under a hood; *r*, rostellum or lip covering the stigmatic surface; *st*, stigma which is much branched or plume-like; *o*, ovary; *se*, sepals; *p*, petals; *l*, labellum or modified petal.

[1] Central Experiment Station Contribution No. 1727. Read at an Agronomy seminar on June 30, 1953. All drawings in this paper are by Mr. Esteban P. Borbe, College illustrator.

and pollen masses are covered by a cup called "hood," and the stigma is hidden by a lip called "lamellum" or "rostellum." These essential parts of the flower do not permit self-pollination. To insure and regulate the production of vanilla pods, it is necessary that the flowers be pollinated by hand.

### POLLINATING THE FLOWERS

In the College of Agriculture vanillery, pollination by hand is performed in the morning from 7 to 9 o'clock when the flowers are open and their stigmas are receptive. In this method, the pollen of a flower is used for pollinating its own stigma. Although cross-fertilization may give better results, it requires more time for transferring the pollen from one flower to the stigma of another.

The three steps in pollinating vanilla flowers by hand are as follows:

1. Detaching the hood which covers the anther and the pollen masses by touching it lightly with a small pointed bamboo stick (fig. 2).

Fig. 2.—The first step in pollinating by hand is detaching the hood which covers the anther and the pollen masses by touching it lightly with a pointed bamboo stick.

Fig. 3.—The second step in pollinating by hand is pushing back the rostellum or lip which covers the anther.

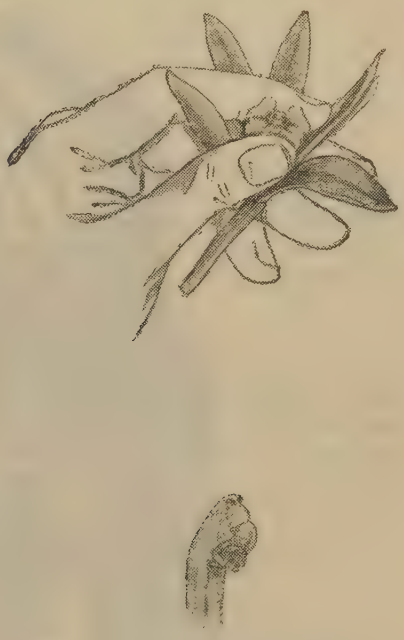


Fig. 4.—The third step in pollinating by hand is gently pressing down with the thumb and forefinger the masses of pollen in the anther on the viscid stigmatic surface.

2. Pushing back the rostellum or lip under the anther (fig. 3).
3. With the thumb and forefinger, gently pressing down the masses of pollen in the anther on the viscid stigmatic surface under the rostellum (fig. 4).

After a little training and practice, laborers can perform the work of pollinating by hand successfully. The petals of a successfully pollinated vanilla flower wither, but they persist on the pod until the latter is nearly ripe (fig. 5). If the flower and its petals fall off, fertilization has not taken place. One laborer can pollinate from 120 to 150 flowers in two hours, depending on the availability of flowers within his reach on the vines. Sometimes a ladder is necessary to enable the pollinator to reach the flowers.

A good vanilla plant in the College cultures produces about one hundred racemes. One raceme (fig. 5) has 10 to 20 flowers, of which

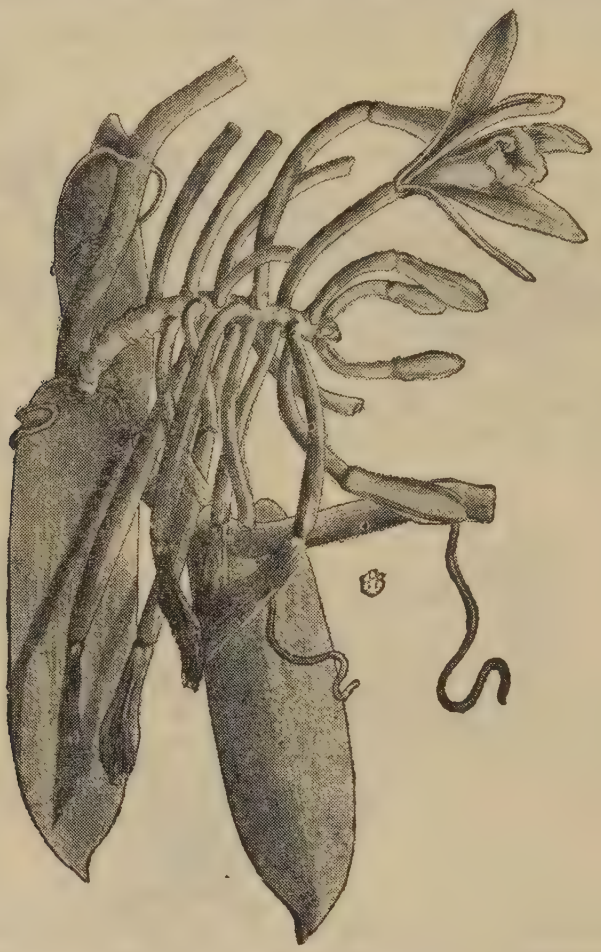


Fig. 5.—Portion of a vanilla vine with a raceme containing buds, an open flower, and five successfully hand-pollinated blossoms.

only five should be fertilized if long pods are to be produced. One good healthy vine may be allowed to produce about one hundred pods, but a weak one, only 50 pods. Vigorous vanilla plants in the College cultures produce an average of 118 pods on 23 racemes. Observation has shown that overcropped plants die soon. The roots, stems, and leaves dry up and the whole vine dies.

The number of vanilla flowers pollinated by one laborer on 84 experimental plants from 7 to 9 o'clock in the morning and the months during which fertilization was carried on are shown below:

| FLOWERING SEASON 1953 | NUMBER OF FLOWERS POLLINATED | SUCCESSFUL POLLINATIONS |
|---|---|---|
| | | *per cent* |
| March | 1,146 | 11.45 |
| April | 7,097 | 70.94 |
| May | 1,327 | 13.26 |
| June | 434 | 4.35 |
| Total | 10,004 | 100.00 |

In the College of Agriculture the height of the flowering season in 1953 was from April to May. A total of 10,004 flowers was pollinated in 83 days at two hours a day, or 60 flowers an hour. Pollination was done on old plants. The pollinator used a ladder to reach the flowers. In the following year, only five flowers in each raceme were fertilized so that long pods would be produced.

### COST OF THE CURED VANILLA PODS FROM ONE PLANT

On the average, a cured vanilla pod weighs 4.21 grams. The cured pods were sold to the Philippine-American Drug Co. (Botica Boie), Manila, at ₱35.20 a kilogram. The income derived from one vanilla plant is shown below:

| | |
|---|---|
| Total number of flowers pollinated by hand from March to June, 1953 | 10,004 |
| Less 20 per cent for those which failed to produce pods (20 × 10,004) | 2,000.8 |
| Number of pods produced | 8,003.2 |
| Total weight of cured pods (8,003.2 × 4.21 grams) | 33.693472 kg. |
| Price of a kilogram (₱35.20 × 33.693472 kg.) | ₱1,186.0102144 |
| Total number of plants | 84 |
| Estimated income from one plant | ₱14.119169219 |

# THE PERFORMANCE OF BERKJALA SOWS FROM SECOND FARROWING TO WEANING[1]

DOLAN ALBAS

The mean number of pigs to the litter at birth was 9.0 ∓ 1.03, and the mean number at weaning was 6.7 ∓ 0.93. The mean weight of the live pigs in the litters at birth was 7.43 ∓ 0.56 kg.; that of the dead pigs was 1.75 kg. The mean weight of weaned pigs was 7.39 ∓ 0.326 kg. The average weight of the pigs that did not reach weaning age was 1.10 kg. The mean differences in weight at birth and at weaning between the male and female pigs were insignificant. There was a marked gain in weight by each pig on the seventh and ninth weeks. The rate of weekly gain in weight was not constant. Of the total number of pigs born, 51.85 per cent were male pigs. About twenty-five per cent of the pigs died before reaching weaning age. The average age of these pigs at the time of death was 13.86 days. The actual amount of feed consumed by the pigs to produce a kilogram gain in weight was 4.52 kg., which was valued at ₱0.654.

In the improvement of swine production through selection of breeding stock, performance, not appearance, has been emphasized as a safe standard by which the productive ability of sows can be measured. However, because of the meager data on the factors affecting the performance of the animals, amateur hog raisers usually eliminate for breeding the sows with poor appearance after the nursing period.

The present study on the performance of Berkjala sows from the second farrowing to weaning is a continuation of the work done by Belen.[2] It was conducted in the Department of Animal Husbandry, College of Agriculture, from November 22, 1949, to March 3, 1951, to determine (1) the number and weight of pigs in the litter at birth and at weaning age; (2) the number and weight of pigs in the litter that did not reach weaning age; (3) the weekly gain in weight of the pigs; (4) the gain or loss in weight of the sows during the nursing period; (5) the sex ratio of the pigs; and (6) the amount and cost of feed consumed by the sows and the pigs.

## MATERIALS AND METHODS

Six Berkjala sows, farrowing for the second time, were housed in hog pens with adjoining outdoor runs. The age of the sows at farrowing ranged from 23 to 31 months. Four of the sows had been used by Belen in the first part of this study.

The sows, as well as the litters, were provided with separate feed containers. They were given identical feed consisting of the follow-

[1] Central Experiment Station Contribution No. 1728. Thesis presented for graduation with the degree of Bachelor of Science in Agriculture from the College of Agriculture. Prepared in the Department of Animal Husbandry under the direction of Associate Professor Mariano Mondoñedo.

[2] Felipe C. Belen, *Philippine Agriculturist*, **37**, 203 (1953).

ing ingredients, all parts by weight: 60 parts fine rice bran, 10 parts ground corn, 20 parts copra meal, and 10 parts fish meal. In addition, one kilogram of ground charcoal and one kilogram of common table salt were added to every 100 kilograms of the feed mixture.

A few days before farrowing, each sow was confined in a clean pen provided either with rice straw or dry cogon for bedding. On the first day after farrowing, the sows were given little or no feed, but they had access to drinking water at all times. They were given one-third of the full ration on the second day, two-thirds on the third day, and the full ration on the fourth day. The sows were fed twice daily and were supplied with sweet potato vines or other green roughage at the rate of one-fourth to one-half kilogram a day. On about the fourth week of the nursing period, when the pigs showed the desire to eat solid feed, they were taught to feed in the adjoining hog runs apart from their mothers.

The sows and their pigs were weighed individually a few hours after farrowing and then weekly thereafter. The last day of the ninth week was taken as the time for weaning the pigs and terminating the experiment.

Body measurements of the sows were taken at farrowing and at weaning to determine the changes during the nursing period. The height was measured vertically from the point of the withers to the floor. The length of the body was measured from the point of the withers to the base of the tail, following the natural curvature of the top line. The heart girth was measured by taking the circumference of the body at the chest just behind the elbow. The depth of the body was measured by resting one point of the caliper on the middle of the top line and the other point on the middle under line of the body. The breadth of the body was measured by placing one point of the caliper on the middle of the right side of the body and the other point on the middle of the left side of the body.

## DISCUSSION OF RESULTS

*Size and weight of litters at birth and at weaning.* The number of pigs in the litters at birth ranged from 6 to 12, the mean being 9.0 ∓ 1.03. This figure is higher than that found by Belen,[3] which was 7.9 ∓ 0.592 pigs to the litter. Carmichael and Rice [4] reported an average of 8.6 pigs to the litter for sows of unknown breed, two years or older and all farrowing for the second time.

The weight of live pigs in the litters at birth ranged from 5.5 to 9.3 kg., with a mean of 7.43 ∓ 0.56. The mean weight of the dead pigs was 1.75 kg.

The number of pigs to a litter at weaning ranged from 3 to 9, with a mean of 6.7 ∓ 0.93 pigs; the mean weight of the litters was

[3] *Ibid.*

[4] W. J. Carmichael and John B. Rice, *Illinois Agric. Exper. Sta. Bull. 226*, 67 (1920).

49.23 ∓ 6.87 kg. The weight of the weaned pigs ranged from 6.19 to 10.25 kg., with a mean of 7.39 ∓ 0.326.

In the first farrowing, Belen noted that the mean weight of the 10 litters at birth, excluding the dead pigs, was 6.39 ∓ 2.206 kg.; that of the dead pigs was 1.97 ∓ 0.563 kg. He also found that the number of pigs weaned to a litter ranged from zero to 10, the mean being 5.20 ∓ 1.123. The mean weight of the litters at weaning was 41.88 ∓ 9.615 kg., and the mean weight of the pigs was 6.199 ∓ 1.121 kg.

*Sex ratio of pigs.* Of the 54 pigs in the six litters studied, 28 were males and 26 were females. The sex ratio in the litter ranged widely from 17.0 to 67.0 per cent. The mean number of male pigs to the litter was 4.7 ∓ 0.92; that of female pigs, 4.3 ∓ 0.49. The ratio of males was 51.85 per cent, which agrees with the finding of Belen that the average ratio of males to the total number of pigs born was 51.9 per cent.

*Average weights of male and female pigs at birth and at weaning.* The mean weight of the males at birth was 0.89 ∓ 0.035 kg.; that of the females was 0.90 ∓ 0.044 kg. The difference in weight of the two sexes, however, was insignificant. At weaning, the mean weight of the males was 7.80 ∓ 0.242 kg.; that of the females, 7.60 ∓ 0.560 kg. The difference was also insignificant.

As noted by Belen, the mean weight of male pigs at birth was 0.95 ∓ 0.031 kg.; that of the females, 0.91 ∓ 0.037 kg. At weaning, the mean weight of the male pigs was 7.30 ∓ 0.731 kg.; that of the female pigs was 7.96 ∓ 0.0590 kg. In both cases, the mean differences were insignificant.

*Mortality.* Of the 54 pigs farrowed by the sows, 14 pigs, or 25.93 per cent, died before weaning. The average age of the pigs that died was 13.86 days. At the time of death, the average weight was 1.10 kg. It was observed that death at birth occurred among heavy as well as relatively light pigs. Mortality was 10 to 15 per cent among the pigs from large litters; no mortality was recorded among those from small litters. Belen noted that the mortality among pigs of the first farrowing was 34.0 per cent.

*Weekly weight and gain in weight of pigs.* The average weight of the live pigs at birth was 0.87 kg.; at one week, 1.65 kg.; at two weeks, 2.42 kg.; at three weeks, 3.10 kg.; at four weeks, 3.59 kg.; at five weeks, 4.23 kg.; at six weeks, 4.90 kg.; at seven weeks, 6.66 kg.; at eight weeks, 6.35 kg.; and at nine weeks, 7.39 kg. On the eighth week there was a loss in weight among the pigs, but the cause was not definitely known.

The average weekly gain in weight of the pigs was 0.78 kg. on the first week; 0.77 kg. on the second week; 0.68 kg. on the third week; 0.49 kg. on the fourth week; 0.64 kg. on the fifth week; 0.67 kg.

on the sixth week; 1.76 kg. on the seventh week; 0.31 kg. on the eighth week; and 1.04 kg. on the ninth week or weaning age. Only the gains in weight in the first two weeks were more or less constant. The highest gain in weight was attained by the pigs at the end of the seventh week. A marked increase in weight was also registered on the ninth week.

The pigs had an average daily gain in weight of 0.111 kg. on the first week; 0.110 kg. on the second week; 0.97 kg. on the third week; 0.070 kg. on the fourth week; 0.091 kg. on the fifth week; 0.096 kg. on the sixth week; 0.251 kg. on the seventh week; 0.044 kg. on the eighth week; and 0.148 kg. on the ninth week.

On the other hand, Belen found that the average weekly gain in weight of each pig ranged from 0.134 to 1.589 kg. and that the average daily gain in weight of each pig ranged from 0.019 to 0.227 kg. for the nine-week period. Judged by the average weekly gain in weight of each pig, the litters of the second farrowing made heavier gains in weight than those of the first farrowing.

*Weight and body measurements of the sows at farrowing and at weaning.* The weight of the sows at farrowing and at weaning varied considerably. The mean weight of the sows at farrowing was 117.88 ∓ 5.38 kg.; that at weaning was 100.03 ∓ 6.64 kg. A significant loss in weight was also found by Belen in sows farrowing for the first time.

Four of the six sows decreased in heart girth. The mean measurement of the heart girth at farrowing was 118.91 ∓ 5.85 cm.; that at weaning was 107.4 ∓ 2.87 cm.

The mean lengths of body were 86.50 ∓ 3.22 cm. at farrowing and 89.67 ∓ 2.38 cm. at weaning.

The depth of body of the sows at farrowing ranged from 42.0 to 58.5 cm., with a mean of 50.25 ∓ 3.40 cm. The measurement at weaning ranged from 45.0 to 57.5 cm., with a mean of 50.57 ∓ 2.41 cm.

At farrowing, the breadth of body was variable, ranging from 26.8 to 39.0 cm., with a mean of 32.60 ∓ 2.14 cm. At weaning, it ranged from 26.0 to 39.0 cm., with a mean of 30.33 ∓ 0.93 cm.

The height at farrowing ranged from 59.0 to 65.5 cm.; that at weaning, from 60.0 to 65.5 cm. The mean heights were 62.12 ∓ 1.03 cm. at farrowing and 62.43 ∓ 1.93 cm. at weaning.

*Loss in weight of the sows and number and weight of litters weaned.* Five sows lost weight but weaned large and heavy litters. The number of pigs weaned was 6 to 9 pigs to a litter, or 77.8 to 100 per cent of the pigs farrowed. Sow No. 234, which had gained three kilograms in weight by the end of the study, weaned only 3 pigs, or 25 per cent of the pigs farrowed.

*Feed consumption of the sows and litters.* During the entire nursing period, the amount of feed consumed by the sows was 1,019.4 kg., or an average of 169.9 kg. for each sow. The average daily ration was 2.48 kg. for each sow.

The litters consumed a total of 114.1 kg. feed during the six weeks of feeding. The average feed consumption of each litter for the six weeks was 19.02 kg., of which 0.72 kg., or 3.8 per cent, was consumed during the fourth week; 1.03 kg., or 5.4 per cent, in the fifth week; 2.42 kg., or 12.7 per cent, in the sixth week; 3.6 kg., or 18.9 per cent, in the seventh week; 4.7 kg., or 24.7 per cent, in the eighth week; and 6.6 kg., or 34.7 per cent, in the ninth week.

During the entire period, the total feed consumption of the sows and the litters was 1,133.5 kg. Calculated on the basis of the total gain in weight of the pigs, the actual amount of feed necessary to produce a kilogram gain in weight was 4.52 kg. At 14.48 centavos a kilogram of feed mixture at the time of the experiment, the actual cost of feed to produce a kilogram gain in weight in the pigs was ₱0.654.

# RESIDUAL EFFECTS OF VARYING AMOUNTS OF FERTILIZER COMBINATIONS UPON THE SUCCEEDING YIELD OF CORN [1]

VALERIANO C. CALMA AND CAMILO N. CALACALA

The percentage of germination of the corn in the plots that received different amounts and combinations of fertilizers during the first planting was from 99 to 100 in the dry-season culture and 100 in the wet-season culture. The percentage of stand for both cultures ranged from 90 to 99. The vigor of plants in the wet-season culture excelled that of the plants in the dry-season culture. The wet-season crop tasseled and matured earlier than the dry-season culture. The mean yield to a plot in the dry-season crop ranged from 2.36 to 3.98 kilograms; in the wet-season crop, from 17.6 to 22.5 kilograms. On the whole, the results showed that the fertilizers applied in different combinations and amounts did not have any residual effects on the second corn crop.

The high cost of maintaining the fertility of land by repeated applications of fertilizers points to a consideration of the residual effects of these fertilizers on the succeeding crop. A survey of the literature reveals that not much work has been done on the subject in the Philippines. Aragon and Esguerra [2] did report, however, that the application of from 50 to 200 kilograms of ammonium sulfate to corn had beneficial residual effects upon the yield of the succeeding rice crop.

To determine the residual effects on the yield of the succeeding corn crop of different amounts and combinations of fertilizers applied to the wet- and dry-season corn cultures in June, 1952, and December, 1952, respectively, an investigation was conducted from November, 1952, to September, 1953, in the Department of Agronomy of the College of Agriculture and Central Experiment Station.

## MATERIALS AND METHODS

*Fertilizers and land used.* The fertilizers [3] used were those previously tried by the senior author and his assistant in June, 1952, and in December, 1952, for the wet- and dry-season cultures, respectively, at 23 different rates of application and N-P-K combinations (table 1).

A relatively uniform upland field of clay loam with an area of 6440 square meters, previously fertilized and cropped to corn, was used for the test cultures. Lime was broadcast evenly over the plots at the rate of two tons to a hectare. Twenty-three different rates of

[1] Central Experiment Station Contribution No. 1729. Prepared from the thesis presented by the junior author for graduation with the degree of Bachelor of Science in Agriculture, October, 1953. The work was conducted under the direction of the senior author.

[2] V. B. Aragon and J. P. Esguerra, *Philippine Agriculturist*, 24, 219 (1935).

[3] Furnished by Mr. Cayetano Pineda of the Fertilizer Administration, Manila.

application and N-P-K combinations were distributed evenly along the furrows of the respective plots at the rate of 350 kilograms of basic fertilizer mixture to a hectare.

*Preparation of the land.* The land was prepared with mechanized equipment according to the ordinary method of preparing a corn field. Twenty-four plots, each five meters by fourteen meters and replicated four times, were laid out following the randomized block design. Five furrows one meter apart were set lengthwise in each plot with a native plow.

*Planting.* For the dry-season culture, seeds of College Yellow Flint were planted on November 26 and 27, 1952; for the wet-season culture, the seeds were planted on May 13 and 14, 1953. The distance of planting was one meter between rows and 0.40 meter between hills in the row. Three to four seeds were planted to a hill at the rate of 25,000 hills to a hectare.

*Care of plants.* Two weeks after planting, the seedlings in each treatment were counted and the percentage of germination was computed. The missing hills were replanted and the hills were thinned to one plant each.

Three weeks after planting, the spaces between the rows of corn were cultivated with an animal-drawn cultivator. Hilling-up was done with a native plow when the plants were four weeks old. Subsequent weeding and cultivation were not necessary as the plants were by then tall enough to overcome the growth of weeds.

*Harvesting, drying, weighing, and shelling.* Harvesting was done when all the plants had matured. In the dry-season culture, the plants in each border row and those within one meter from the ends of each plot were discarded. In the wet-season planting, however, all the plants in each plot were harvested.

The ears were snapped off from the stalks, husked, placed in sacks, and brought to the laboratory. The husked ears were dried thoroughly for sometime in the sun, weighed, shelled with a hand-operated corn sheller, winnowed, and finally weighed.

*Field observations.* The percentage of germination was determined two weeks after planting, and the percentage of stand of plants in each plot, at harvest time. The number of days from planting to tasseling was recorded on the day when the majority of the plants had produced male inflorescences. The attacks of pests and diseases were observed and the approximate loss caused by them was determined. The vigor of the plants at the vegetative and reproductive stages was also observed.

## RESULTS AND DISCUSSION

*Percentages of germination and stand of plants in the field.* The seeds planted in the treated and untreated plots of all the blocks of both the dry- and wet-season cultures germinated at practically the

same time, four days after planting. The percentage of germination in the dry-season culture ranged from 99 to 100. The wet-season culture had 100 per cent germination.

The percentage of stand ranged from 90 to 99 for both the dry- and wet-season cultures.

*Damage by pests, diseases, and typhoons.* In both the dry- and wet-season crops, slight damage was inflicted by corn borer (*Pyrausta nubilalis* Hübner) and by corn ear worm (*Heliothis armigera* Hübner).[4] No diseases were found on either culture.

Heavy rainfall three weeks after planting, from December 17 to 22, 1952, affected adversely the growth of the plants in the dry-season culture since the lower portions of the field, especially in replications 3 and 4, became water-logged. A strong wind on August 10 to 13, 1953, caused the stalks of all the plants of the four replications of the wet-season culture to bend slightly as they approached maturity. No stalks, however, were broken.

*Vigor of plants.* The relative vigor exhibited by the plants showed that the wet-season culture surpassed the dry-season crop with respect to the appearance of the plants as a whole. The plots which were previously fertilized were darker green and more vigorous than the controls for both cultures. However, the plants in plots which were poorly drained and water-logged were stunted and pale green. The dry-season culture plants suffered the most, especially some of the plots in replications 3 and 4. Three weeks after the dry-season crop had been planted, it rained heavily for six days, affecting adversely the growth of the plants.

*Flowering and maturity periods.* The plants of the dry-season culture tasseled and matured later than those of the wet-season crop. This may be partly explained by the difference in photoperiodism between the dry- and wet-season cultures. In the dry-season culture, the plants tasseled 45 days after planting. The wet-season crop tasseled in 41 days. It took the dry-season culture 105 days to mature, and the wet-season culture, 97 days.

*Yield.* The yields of grains in the dry-season culture (table 1) showed that the treatment with 18–12–12 plus side dress gave the highest mean yield of 3.98 kilograms, and the treatment with 12–0–12 plus side dress gave the lowest, 2.36 kilograms. When all the treatments were compared statistically, however, the mean yields were equal.

The mean yields in the wet-season planting ranged from 17.6 kilograms for the untreated plot to 22.5 kilograms for the plot treated with 0–12–12 plus side dress (table 2). The yields did not differ when compared statistically.

It can be deduced from the results that the fertilizers applied during the first planting did not at all influence the yield of corn

[4] Identified by Dr. Silverio M. Cendaña of the Department of Entomology.

in the second or succeeding planting. The fertilizers applied during the final planting might have been lost through crop absorption, leaching, soil erosion, or fixing by the soil particles. This conclusion is supported by the results of the chemical analysis of the soils made in the Department of Soils. All the plots showed an average pH-value of 6.0, except the one treated with two tons of lime to a hectare which had a pH-value of 6.6. Galvez and Bueno [5] found that the addition of physiologically acidic ammonium sulfate fertilizer had no significant effect on the pH-values of the soil, presumably because the soil materials were not only highly buffered but also resistant to the reaction of the fertilizer and to the physical, chemical, and biological forces in the soil. It may be inferred, therefore, that the development of soil acidity is not an instantaneous reaction but a slow process.

The application of complete fertilizers with varying N-P-K ratios failed to cause marked changes in the concentrations of nitrogen and sodium acetate-acetic acid, soluble phosphoric acid, and potash of the soil. Both the control and the treated plots were deficient in nitrogen. Galvez and Bueno [6] found that when leaching was allowed, the fertility of the treated lot was equal to that of the untreated lot. They, therefore, recommended the addition of the usual amount of fertilizer for every planting. Phosphoric acid and potash, which are recognized to be fixed by the soil colloids and released later on for the following crops, generally were of similar amounts in both the control and treated lots irrespective of their concentration. This is contrary to present speculation.

---

[5] N. L. Galvez and P. M. Bueno, *Philippine Agriculturist*, 35, 75 (1952).
[6] *Ibid.*

TABLE 1

*Mean yields of grains in kilograms*
*(dry-season culture)*

| TREATMENT | REPLICATION | | | | TOTAL | MEAN |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | | |
| Control | 4.929 | 2.414 | 2.681 | 1.131[b] | 11.155 | 2.789 |
| 0–12–12 plus side dress | 3.748 | 3.817 | 2.294 | 3.537 | 13.396 | 3.349 |
| 6–12–12 plus side dress | 5.692 | 3.598 | 2.930 | 2.100 | 14.320 | 3.580 |
| 12–12–12 plus side dress | 4.380 | 2.823 | 2.380 | 1.450 | 11.033 | 2.758 |
| 18–12–12 plus side dress | 5.656 | 4.962 | 2.178 | 3.126 | 15.922 | 3.980 |
| 24–12–12 plus side dress | 4.994 | 2.837 | 1.703 | 1.828 | 11.362 | 2.840 |
| 12– 0–12 plus side dress | 4.287 | 1.710[b] | 1.471[b] | 1.973[b] | 9.441 | 2.360 |
| 12– 6–12 plus side dress | 5.542 | 3.041 | 3.376 | 2.644 | 14.603 | 3.651 |
| 12–18–12 plus side dress | 3.710 | 4.607 | 1.778 | 1.917[b] | 12.012 | 3.003 |
| 12–24–12 plus side dress | 5.781 | 4.682 | 1.898[b] | 1.694[b] | 14.055 | 3.514 |
| 12–12– 0 plus side dress | 5.656 | 2.461 | 1.521[b] | 3.627 | 13.265 | 3.316 |
| 12–12– 6 plus side dress | 4.627 | 3.730 | 2.655 | 2.527 | 13.539 | 3.385 |
| 12–12–18 plus side dress | 5.590 | 4.676 | 1.752 | 1.856 | 13.874 | 3.468 |
| 12–12–24 plus side dress | 3.281 | 4.685 | 3.910 | 2.981 | 14.857 | 3.714 |
| 12–12–12 plus side dress plus lime | 4.326 | 2.800 | 1.020[c] | 2.537 | 10.683 | 2.671 |
| 12–12–12 no side dress | 4.040 | 4.585 | 1.473 | 1.983[b] | 12.081 | 3.020 |
| 12–12–12 as side dress | 4.020 | 2.516 | 3.000 | 2.328 | 11.864 | 2.966 |
| 12–12–12 at one-half rate plus side dress | 3.391 | 2.376 | 3.539 | 1.409 | 10.715 | 2.679 |
| 12–12–12 at double rate plus side dress | 4 .248 | 3.466 | 1.932 | 3.941 | 13.587 | 3.397 |
| 12–12–12 plus 100 kg. $(NH_4)_2SO_4$ to a hectare as side dress | 4.298 | 3.453 | 2.597 | 1.081[b] | 11.431 | 2.858 |
| 12–12–12 plus 200 kg. $(NH_4)_2SO_4$ to a hectare as side dress | 4.433 | 2.782 | 1.898[b] | 1.578[b] | 10.691 | 2.673 |
| 12–12–12 plus 300 kg. $(NH_4)_2SO_4$ to a hectare as side dress | 4.819 | 2.945 | 3.314 | 2.280 | 13.358 | 3.339 |
| 12–12–12 plus 400 kg. $(NH_4)_2SO_4$ to a hectare as side dress | 4.431 | 3.112 | 1.009[c] | 2.135 | 10.687 | 2.672 |
| Total | 105.879 | 78.080 | 52.309 | 51.663 | 287.931 | |
| Mean | 4.603 | 3.395 | 2.274 | 2.246 | | |

[a] Treatments based on 350 kilograms of basic fertilizer to a hectare, side-dressed with 350 kilograms of ammonium sulfate.
[b] Sometimes partly water-logged.
[c] Frequently water-logged.

*Analysis of variance*

| SOURCE OF VARIATION | DF | SUM OF SQUARES | VARIANCE | COMPUTED F-VALUE | TABULAR F-VALUE | |
|---|---|---|---|---|---|---|
| | | | | | 5% | 1% |
| Replication | 3 | 86.35 | 28.78 | | | |
| Treatment | 22 | 15.83 | 0.72 | 1.09 | 1.7 | 2.4 |
| Interaction | 66 | 43.56 | 0.66 | | | |
| Total | 91 | 145.74 | | | | |

TABLE 2

*Mean yields of grains in kilograms*
*(wet-season culture)*

| TREATMENT [a] | REPLICATION | | | | TOTAL | MEAN |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | | |
| Control | 21.2 | 19.2 | 20.0 | 11.1 [b] | 70.6 | 17.6 |
| 0–12–12 plus side dress | 20.3 | 23.2 | 23.8 | 21.8 | 90.0 | 22.5 |
| 6–12–12 plus side dress | 19.8 [b] | 20.4 | 20.2 | 19.0 | 79.4 | 19.8 |
| 12–12–12 plus side dress | 24.4 | 19.3 | 21.0 | 18.2 | 82.9 | 20.7 |
| 18–12–12 plus side dress | 21.2 | 21.1 | 21.4 | 19.2 | 82.9 | 20.7 |
| 24–12–12 plus side dress | 22.3 | 23.4 | 18.2 | 23.0 | 86.9 | 21.7 |
| 12– 0–12 plus side dress | 21.3 | 20.9 | 20.6 | 21.1 | 83.9 | 20.9 |
| 12– 6–12 plus side dress | 21.8 | 19.7 | 23.2 | 19.2 | 83.9 | 20.9 |
| 12–18–12 plus side dress | 19.9 | 18.8 | 24.7 | 8.3 [c] | 71.7 | 17.9 |
| 12–24–12 plus side dress | 20.2 | 22.3 | 21.1 | 17.8 | 81.4 | 20.3 |
| 12–12– 0 plus side dress | 22.8 | 18.1 [b] | 21.5 | 17.8 | 80.2 | 20.0 |
| 12–12– 6 plus side dress | 19.4 | 22.5 | 22.4 | 17.6 | 81.9 | 20.5 |
| 12–12–18 plus side dress | 23.5 | 22.6 | 19.2 [b] | 22.6 | 87.9 | 21.9 |
| 12–12–24 plus side dress | 23.1 | 19.3 | 25.4 | 12.8 [c] | 80.6 | 20.1 |
| 12–12–12 plus side dress plus lime | 21.8 | 25.2 | 23.2 | 12.8 [c] | 83.0 | 20.7 |
| 12–12–12 no side dress | 21.2 | 23.6 | 20.2 | 18.0 | 83.0 | 20.7 |
| 12–12–12 as side dress | 22.9 | 18.3 | 18.2 | 15.7 | 75.1 | 18.8 |
| 12–12–12 at one-half rate plus side dress | 20.5 | 17.3 [b] | 19.5 | 18.1 | 75.4 | 18.8 |
| 12–12–12 at double rate plus side dress | 22.2 | 22.1 | 22.1 | 18.1 | 84.5 | 21.1 |
| 12–12–12 plus 100 kg. $(NH_4)_2SO_4$ to a hectare as side dress | 23.7 | 21.9 | 21.9 | 20.8 | 88.3 | 22.1 |
| 12–12–12 plus 200 kg. $(NH_4)_2SO_4$ to a hectare as side dress | 22.9 | 23.9 | 22.1 | 16.0 [b] | 84.9 | 21.2 |
| 12–12–12 plus 300 kg. $(NH_4)_2SO_4$ to a hectare as side dress | 19.5 | 22.3 | 20.2 | 18.4 | 80.4 | 20.1 |
| 12–12–12 plus 400 kg. $(NH_4)_2SO_4$ to a hectare as side dress | 22.1 | 24.1 | 21.1 | 17.4 [b] | 84.7 | 21.2 |
| Total | 498.0 | 489.5 | 491.2 | 404.8 | 1883.5 | |
| Mean | 21.7 | 21.3 | 21.4 | 17.6 | | |

[a] Treatments based on 350 kilograms of basic fertilizer to a hectare, side-dressed with 350 kilograms of ammonium sulfate.
[b] Sometimes partly water-logged.
[c] Frequently water-logged.

*Analysis of variance*

| SOURCE OF VARIATION | DF | SUM OF SQUARES | VARIANCE | COMPUTED F-VALUE | TABULAR F-VALUE | |
|---|---|---|---|---|---|---|
| | | | | | 5% | 1% |
| Replication | 3 | 254.85 | 84.95 | | | |
| Treatment | 22 | 134.28 | 6.10 | 1.06 | 1.7 | 2.4 |
| Interaction | 66 | 378.95 | 5.74 | | | |
| Total | 91 | 768.08 | | | | |

# THE INFLUENCE OF LENGTH OF GRAZING ON EGG PRODUCTION [1]

RICHARD PANG

The birds that were allowed to graze the whole day increased the heaviest in weight and had the lowest mortality. Mortality was highest among the confined birds given no green feed. The percentage of egg production was higher among the confined birds without green feed than among the birds that were allowed to graze in the morning and the confined birds given green feed. The birds that were allowed to graze the whole day produced the deepest orange-yellow yolks; the confined birds that were not provided with green feed produced pale orange-yellow yolks. A long grazing period favorably influenced the returns and cost of egg production and the size and hatching quality of the eggs produced.

Limited space in cities and suburbs where chickens are now raised makes it necessary that they be raised in confinement. One obvious shortcoming of this method of poultry management is that the birds are deprived of the green feeds which they can obtain on the range.

Elvehjem and Sober (1943) showed that grasses contain appreciable amounts of many well-known nutrients and are rich in unknown factors. Parker and McSpadden (1943) also reported that the use of pasture resulted in rapid gain in weight, less feed consumption, and better vigor and viability. Heuser (1946) stated that the value of green feed was first noted in birds that had been turned on the range after confinement. He also said that egg production was retarded when the natural supply of green feed was low. Bice (1947) reported that one of the best green feeds for poultry is finely chopped, green lawn grass. Morrison (1948) stated that egg production was generally unsatisfactory when the hens were not supplied with fresh green feed. Misner (1931), on the other hand, reported that no change in the egg production of each bird was found when green feed was given.

This work was conducted in the Department of Animal Husbandry from July 1, 1951, to June 30, 1952, to determine whether or not length of grazing influences egg production.

## MATERIALS AND METHODS

One hundred and twenty New Hampshire pullets that were just beginning to lay were divided into four lots of 30 pullets each. On June 26, 1951, the birds were transferred from the rearing yard to the laying house. Actual observations, however, were first made

[1] Central Experiment Station Contribution No. 1730. Thesis presented for graduation with the degree of Bachelor of Science in Agriculture from the College of Agriculture. Prepared in the Department of Animal Husbandry under the direction of Professor F. M. Fronda and Instructor A. C. Campos.

on July 1, 1951, when all the birds were weighed. Thereafter, until the end of the experiment, the bimonthly weights of the birds were recorded.

The different lots were managed differently. Lot I was allowed to graze all day, from six o'clock in the morning to six o'clock in the evening. Lot II was allowed to graze only in the morning, from six o'clock in the morning to twelve o'clock noon. Lot III was not allowed to graze at all. Instead it was supplied at ten o'clock in the morning with finely chopped lawn grass. The birds were given all they could consume in about one hour, and the amount consumed daily was recorded. Lot IV, the control for the three other lots, was confined in the laying house. No green feed was given to this lot.

Lots I and II were provided with a 159-square-meter grassy yard. Each laying house had an area of six square meters, and each bird had a floor space of approximately two-tenths square meter. The feeding and the watering troughs were placed inside the laying houses and were left open to the birds at all times.

The lots were given the College all-mash laying ration consisting of the following ingredients, all parts by weight:

| | |
|---|---|
| Ground corn | 50 |
| Rice bran | 20 |
| Copra meal | 10 |
| Fish meal | 20 |
| Common table salt | 1% |

The birds had free access to grit and ground shells. Except for the varying lengths of grazing period and the use of green feed, all the lots were given identical management and care.

On October 2, 1951, two roosters were placed with each lot. Observations on the fertility and hatchability of the eggs were made from October 10 up to the end of the experiment. The birds were trapnested, and the eggs laid during the first week of each month were weighed individually.

The kinds of green feed [2] found growing in the yard were *Echinochloa colonum* (L) Link., *Digitaria macrobachne* (Roxb.) Merr., *Panicum flavidum* Retz., *Panicum distachyum* Linn., *Eleusine indica* (Linn.) Gaertn., *Paspalum conjugatum* Berg, *Kyllinga monocephala* Rottb., *Cynodon dactylon* (Linn.) Pers., *Paspalum scrobiculatum* Linn., and *Cyperus rotundus* Linn.

## RESULTS AND DISCUSSION

*Grazing habits of the birds.* When the back doors of the laying houses of lots I and II were opened early in the morning, most of the birds would go out immediately and graze in the yard. After five to ten minutes, they would enter the laying houses and feed in the mash troughs.

[2] Identified in the Department of Agricultural Botany.

At first the birds grazed on the grasses growing near the laying houses, but from eight o'clock to nine o'clock they were observed to be grazing farther away. Between eleven o'clock in the morning and two o'clock in the afternoon, the birds in lot I sought shelter in the shade and inside the laying houses. Late in the afternoon these birds were observed to be grazing all over the yard. Manuel (1949) observed similar grazing habits among chicks on the range.

*Weight and health of the birds.* In general, the birds allowed to graze the whole day gained the heaviest in weight (table 1). They were healthier and more vigorous than the other birds, as shown by the redness of their combs and the glossiness of their feathers. The birds were very active in the yard. According to Heuser (1946), grasses stimulate the health of the birds and act as a health preserver. This probably explains why lot I had the lowest rate of mortality (table 1).

*Mortality.* The mortality during the entire experiment is recorded in table 1. Most of the deaths in lots III and IV were due to leucosis complex.[3] There were two cases in lot III of death from internal parasites. On January 22, 1952, bird number 295 in lot III was observed to be inactive. On the third day, the bird was found dead on the floor. Post-mortem examination showed that the bird was heavily infested with *Ascaridia galli* Shrank. Except for one case of leucosis complex in lot II, most of the deaths in lots I and II were caused by internal parasites.

The percentages of mortality indicate that the longer the grazing period, the lower the mortality rate. The limited floor and yard areas may have also influenced the mortality rate of the birds. Parker and McSpadden (1944) concluded that it is possible to reduce the mortality in growing pullets by having a good pasture crop on the range.

*Feed consumption and cost.* On the basis of the average feed consumed by each bird in lot IV, lot I made a saving, as a result of using green feed, of 2.16 kg., or 7.01 per cent; lot II, 2.04 kg., or 6.62 per cent; and lot III, 0.86 kg., or 2.78 per cent. According to Davidson, Rather, and Card (1943), a good pasture will result in a saving of 10 to 20 per cent of the feed. Weinmiller (1936), comparing pullets grown on grass with those confined, reported a saving of 10 per cent in feed for the pasture group.

*Amount of feed needed to produce a dozen eggs.* Lot III required the most feed to produce a dozen eggs (table 4), perhaps partly because of the presence of more lice and internal parasites in this lot than in the other lots. Because these parasites disturbed the physiological condition of the birds, egg production was also affected. Some of the feed consumed by the birds was not utilized for egg production but was used up by the parasites.

[3] Dr. Faustino S. Mensalvas of the Department of Animal Husbandry identified the diseases mentioned in this paper.

*Number of eggs produced.* The distribution of egg production (table 2) showed that there was a decrease in December because of the occurrence of several storms during that month. Fronda (1935) reported that storms caused a decrease in daily egg production. On the average, lot IV had a higher percentage of egg production than lots II and III. The difference may be partly attributed to the presence of more broody birds in the lots that received green feed. Five birds were broody in lot I, four in lot II, six in lot III, and only two in lot IV. The bigger amount of feed consumed by each bird in lot IV may have also contributed to the higher rate of egg production in that lot. The significance of the differences between lots was not ascertained because the data could not be treated statistically.

As a whole, no consistent beneficial effect on egg production was obtained with the use of green feed. However, on the basis of other criteria such as gain in weight by each bird, mortality, and the quality of eggs produced, green feed had a markedly favorable effect on the birds. It is possible that the pullets, being in the best of condition at the start of the experiment, were able to stand unfavorable environment for some time without any adverse effect on egg production. Again, a year's time may not have been long enough to exhaust the resistance of the birds. An extended experiment may make the results more conclusive.

*Weight of eggs.* All the eggs produced during the first week of the month were weighed individually. Marked differences were observed in the average weights of the eggs of the different lots (table 3). Parkhurst (1933) also found green feed to be of value in increasing egg size.

*Color and size of the yolks.* In February and June, sample eggs from each lot were broken, and the yolks were compared for intensity of color. Lot I had the deepest orange-yellow yolks. Lots II and III had lighter orange-yellow yolks, and lot IV had pale orange-yellow yolks. Stephenson and Bryant (1944) found that the pullets which had been allowed free range consistently produced darker yolks than those which had been confined. According to Parker and McSpadden (1943) who used the Heiman-Carver egg color rotor, the yolk color of the eggs produced by birds on pasture was more uniform, varying only between two shades, whereas that in the nonpasture group showed considerably more variation.

The egg yolks in lot I had an average diameter of 4.2 centimeters; those in lot II, 3.7; and those in lots III and IV, 3.5. The albumen of the eggs in the grazing lots was thicker than those in the confined lots. The increase in the size of the yolk may be attributed to the grazing period. The longer the birds were allowed to stay in the yard, the greater the amount of vitamin D they received. There may have also been other unidentified factors in the yard and in the grasses which affected the size and the color of the yolk.

*Incubation results.* One week after the roosters had been placed in the laying houses, the eggs were saved for incubation. Monthly incubation tests were made from October, 1951, to June, 1952. Lot I had the highest annual percentages of fertility (84.2) and hatchability (74.3), followed by lots II, III, and IV in the descending order (table 5). Parker and McSpadden (1943) also observed that the hatchability in the pen provided with pasture was over 75 per cent, whereas that in the bareyard ground was only 50 per cent. The results obtained in this investigation show that the length of the grazing period influenced favorably the hatchability of the eggs.

## LITERATURE CITED


BICE, CHARLES M. 1947. Poultry production in Hawaii. x + 246 p., 71 fig. Honolulu: Honolulu Star Bulletin.

DAVIDSON, J. A., H. C. RATHER, AND G. C. CARD. 1943. Observation of feedstuffs through turning pullets on pasture. Michigan Agric. Exper. Sta. Quart. Bull. 25: 324–329.

ELVEHJEM, C. A., AND H. A. SOBER. 1943. The nutritional significance of grass. Chronica Bot. 7: 301.

FRONDA, F. M. 1935. Observations on the effect of some storms on egg production. Philippine Agriculturist 24: 229–238. *Fig. 1, charts 1–4.*

HEUSER, GUSTAVE F. 1946. Feeding poultry. vii + 543 p. New York: John Wiley and Sons, Inc.

MANUEL, AVELINO B. 1949. Observations on the range habits of growing chicks. Philippine Agriculturist 33: 28–35.

MISNER, E. G. 1931. Economic studies of poultry farming in New York. III. Department of Agricultural Economics, N. Y. State College of Agriculture. *Cited in* Heuser, G. F. 1946. Feeding poultry. vii + 543 p. New York: John Wiley and Sons, Inc.

MORRISON, FRANK B. 1948. Feeds and feeding. 21st ed., vi + 1207 p. New York: Morrison Publishing Co.

PARKER, JESSE E., AND E. J. MCSPADDEN. 1943. Pasture studies with laying hens. II. Simple rations with and without pasture. Tennessee Agric. Exper. Sta. Bull. 185: 11–19.

———. 1944. Pasture for growing pullets. Tennessee Agric. Eper. Sta. Bull. 188: 1–14.

PARKHURST, R. T. 1933. Some factors affecting egg weight in the domestic fowl. Poultry Sci. 12: 97. *Cited in* Heuser, G. F. 1946. Feeding poultry. vii + 543 p. New York: John Wiley and Sons, Inc.

STEPHENSON, A. B., AND R. L. BRYANT. 1944. The value of a sod range for starting chicks, growing pullets and laying hens. Virginia Agric. Exper. Sta. Bull. 362: 1–18.

WEINMILLER, L. 1936. Untersuchungen uber den Futterwert der Huhnerweide. Report, Sixth World's Poultry Congress 1936: 363. *Cited in* Heuser, G. F. 1946. Feeding poultry. vii + 543 p. New York: John Wiley and Sons, Inc.

TABLE 1

*Influence of length of grazing upon the weight and mortality of the birds*

| ITEM | LOT I | LOT II | LOT III | LOT IV |
|---|---|---|---|---|
| | All-day grazing | Half-day grazing | Supplied with chopped green feed for one hour | No green feed |
| Number of birds at start of experiment, July 1, 1951 | 30 | 30 | 30 | 30 |
| Number of birds at end of experiment, June 30, 1952 | 27 | 24 | 23 | 22 |
| Average weight of bird at start of experiment, grams | 1,379.3 | 1,422.0 | 1,430.4 | 1,409.3 |
| Average weight of bird at end of experiment, grams | 1,983.3 | 2,000.8 | 1,858.3 | 1,934.6 |
| Average increase in weight, grams | 604.0 | 578.8 | 427.9 | 525.3 |
| Percentage increase in weight [a] | 43.8 | 40.7 | 29.9 | 37.3 |
| Number of birds that died during the experiment [b] | 2 | 5 | 6 | 8 |
| Percentage mortality for the year | 6.9 | 17.2 | 20.7 | 26.7 |

[a] Based on the average weight of the birds at the beginning of the experiment.
[b] One bird each from lots I, II, and III was missing on January 4, 1952.

TABLE 2

*Distribution of egg production as influenced by length of grazing period*

| PERIOD | LOT I | | LOT II | | LOT III | | LOT IV | |
|---|---|---|---|---|---|---|---|---|
| | Number of eggs laid | Percentage of egg production | Number of eggs laid | Percentage of egg production | Number of eggs laid | Percentage of egg production | Number of eggs laid | Percentage of egg production |
| July, 1951 | 84 | 9.03 | 121 | 13.01 | 140 | 15.19 | 74 | 7.95 |
| August, 1951 | 197 | 21.18 | 274 | 29.46 | 198 | 22.03 | 167 | 19.58 |
| September, 1951 | 305 | 33.89 | 287 | 32.47 | 228 | 27.34 | 325 | 40.22 |
| October, 1951 | 393 | 42.26 | 406 | 45.16 | 316 | 39.03 | 340 | 43.87 |
| November, 1951 | 375 | 41.67 | 306 | 35.17 | 303 | 38.85 | 265 | 35.33 |
| December, 1951 | 346 | 37.20 | 329 | 36.60 | 303 | 37.59 | 262 | 33.80 |
| January, 1952 | 350 | 38.80 | 469 | 53.61 | 320 | 40.15 | 353 | 45.98 |
| February, 1952 | 470 | 55.89 | 408 | 50.25 | 389 | 54.20 | 428 | 61.49 |
| March, 1952 | 495 | 56.57 | 394 | 46.97 | 341 | 47.20 | 403 | 56.37 |
| April, 1952 | 407 | 48.45 | 355 | 43.82 | 286 | 41.45 | 338 | 50.38 |
| May, 1952 | 369 | 44.03 | 239 | 30.07 | 249 | 34.93 | 287 | 42.08 |
| June, 1952 | 293 | 36.17 | 170 | 23.61 | 197 | 28.55 | 206 | 31.21 |
| Annual | 4084 | 38.43 | 3758 | 36.62 | 3160 | 33.69 | 3448 | 37.08 |

TABLE 3

*Average weight of one egg during the different months of the year* [a]

| PERIOD | LOT I | | LOT II | | LOT III | | LOT IV | |
|---|---|---|---|---|---|---|---|---|
| | Number of eggs weighed | Weight of egg | Number of eggs weighed | Weight of egg | Number of eggs weighed | Weight of egg | Number of eggs weighed | Weight of egg |
| | | *grams* | | *grams* | | *grams* | | *grams* |
| July, 1951 | 7 | 34.9 | 10 | 40.4 | 14 | 41.5 | 7 | 40.1 |
| August, 1951 | 43 | 48.1 | 61 | 49.1 | 44 | 48.1 | 30 | 46.5 |
| September, 1951 | 54 | 52.9 | 51 | 51.1 | 52 | 48.6 | 62 | 49.6 |
| October, 1951 | 78 | 53.8 | 93 | 52.4 | 47 | 50.4 | 77 | 48.1 |
| November, 1951 | 85 | 56.2 | 77 | 51.5 | 75 | 48.1 | 72 | 50.2 |
| December, 1951 | 84 | 57.3 | 63 | 54.2 | 78 | 53.2 | 60 | 51.1 |
| January, 1952 | 63 | 56.7 | 87 | 54.3 | 61 | 53.9 | 71 | 52.2 |
| February, 1952 | 86 | 62.3 | 91 | 54.8 | 83 | 49.9 | 87 | 52.9 |
| March, 1952 | 113 | 54.7 | 81 | 53.1 | 83 | 51.1 | 85 | 51.0 |
| April, 1952 | 80 | 57.2 | 74 | 58.6 | 68 | 49.2 | 65 | 47.5 |
| May, 1952 | 32 | 57.9 | 30 | 56.1 | 28 | 55.2 | 33 | 47.0 |
| June, 1952 | 44 | 57.3 | 39 | 53.1 | 27 | 54.1 | 33 | 48.7 |
| Annual | 769 | 56.0 | 757 | 53.3 | 660 | 50.6 | 682 | 49.9 |

[a] The average weight of one egg was based on the total number of eggs collected during the first week of each month.

TABLE 4

*Amount and cost of feed consumed as influenced by length of grazing period*

| ITEM | LOT I | LOT II | LOT III | LOT IV |
|---|---|---|---|---|
| Total amount of feed consumed, kg. | 869.90 | 849.05 | 808.50 | 798.20 |
| Total cost of feed consumed, pesos [a] | 254.88 | 248.77 | 236.16 | 233.87 |
| Average feed consumed by each bird, kg. | 28.64 | 28.76 | 29.94 | 30.80 |
| Cost of feed consumed by each bird, pesos | 8.38 | 8.43 | 8.77 | 9.03 |
| Total amount of chopped green feed given, kg.[b] | — | — | 98.48 | — |
| Total number of eggs produced | 4084 | 3758 | 3160 | 3448 |
| Value of eggs produced, pesos [c] | 680.66 | 626.34 | 526.66 | 574.66 |
| Amount of feed needed to produce a dozen eggs, kg. | 2.67 | 2.71 | 3.07 | 2.78 |
| Cost of feed needed to produce a dozen eggs, pesos | 0.78 | 0.79 | 0.89 | .081 |
| Returns above cost of feed consumed, pesos | 425.78 | 377.57 | 290.50 | 340.79 |

[a] Based on average cost, ₱.293 a kilogram.
[b] Fresh weight.
[c] Based on the average market price of ₱2.00 a dozen.

TABLE 5

*Influence of length of grazing period on the fertility and hatchability of the eggs* [a]

| | LOT I | | | LOT II | | | LOT III | | | LOT IV | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Number of eggs set | Fertility | Hatchability | Number of eggs set | Fertility | Hatchability | Number of eggs set | Fertility | Hatchability | Number of eggs set | Fertility | Hatchability |
| | | *per cent* | *per cent* | | *per cent* | *per cent* | | *per cent* | *per cent* | | *per cent* | *per cent* |
| Oct., 1951 ... | 128 | 94.5 | 66.1 | 119 | 73.1 | 55.2 | 80 | 50.0 | 47.5 | 88 | 73.9 | 40.0 |
| Nov., 1951 ... | 173 | 90.2 | 77.6 | 131 | 86.3 | 57.5 | 122 | 61.5 | 49.3 | 113 | 78.8 | 43.8 |
| Dec., 1951 ... | 259 | 85.3 | 72.4 | 184 | 92.9 | 51.5 | 169 | 79.9 | 45.1 | 134 | 71.6 | 48.8 |
| Jan., 1952 ... | 188 | 87.2 | 76.2 | 194 | 89.2 | 54.8 | 127 | 90.6 | 51.0 | 134 | 76.1 | 44.1 |
| Feb., 1952 ... | 264 | 89.0 | 76.1 | 200 | 91.0 | 57.1 | 162 | 89.5 | 63.4 | 172 | 68.6 | 38.1 |
| March, 1952 . | 106 | 89.6 | 74.7 | 165 | 83.1 | 77.8 | 56 | 82.1 | 71.7 | 44 | 72.1 | 59.4 |
| April, 1952 .. | 65 | 81.5 | 75.5 | 42 | 67.5 | 55.2 | 29 | 72.4 | 76.2 | 43 | 83.7 | 69.4 |
| May, 1952 ... | 114 | 57.9 | 77.2 | 56 | 50.0 | 57.1 | 61 | 70.5 | 60.5 | 66 | 62.1 | 58.5 |
| June, 1952 .. | 80 | 81.3 | 71.4 | 45 | 62.2 | 64.3 | 35 | 54.3 | 52.6 | 53 | 50.9 | 51.9 |
| Total ..... | 1377 | 84.2 | 74.3 | 1136 | 76.3 | 60.3 | 841 | 75.9 | 59.9 | 847 | 71.5 | 46.2 |

[a] The percentage of fertility was based on the total number of eggs set for the month; percentage of hatchability, on the total number of fertile eggs.

# BUILT-UP FLOOR LITTER FOR BROODING CHICKS [1]

A. C. Campos and M. P. Cruz

WITH ONE TEXT FIGURE

The chicks raised on built-up litter grew consistently faster, suffered less mortality, and required a little less feed to produce a kilogram gain than those raised on fresh litter. The results tend to show that old built-up litter may be used to advantage, not only because it is labor saving, but also because it has growth-promoting properties.

Kennard and Chamberlin (1948) first reported experimental proof of the value of built-up floor litter [2] to growing chicks. Since then built-up floor litter has become very popular and is now widely used by American poultrymen. Although skeptical about its use, a number of Filipino poultry raisers have started raising their chicks on this kind of litter. This study was conducted in the Department of Animal Husbandry from May, 1952, to March, 1953, to determine the effect of built-up litter on the growth and mortality of chicks raised locally.

## MATERIALS AND METHODS

A total of 146 day-old New Hampshire chicks was used in two trials, each covering a period of 12 weeks and consisting of two lots. The first trial, which had 50 chicks to each lot, lasted from June 11 to September 3, 1952; the second, which had 23 chicks to a lot, was conducted from September 15 to December 8, 1953.

The College all-mash ration for chicks was given to both lots in both trials. This ration consists of the following ingredients, all parts by weight:

| | |
|---|---|
| Rice bran | 55 |
| Corn, ground | 20 |
| Copra meal | 5 |
| Fish meal | 20 |
| | 100 |

In addition, chopped green feed and ground shells and grit were given the birds when they were four weeks old. The mash was

[1] Central Experiment Station Contribution No. 1731. The data in this paper were intended for the thesis to be presented for the degree of Bachelor of Science in Agriculture by the junior author, who was posthumously graduated in April, 1953. The work was prepared in the Department of Animal Husbandry under the direction of the senior author.

[2] Built-up floor litter refers to old litter previously used by successive broods of chicks. The original fresh litter is left in the brooder house after the first brood is weaned, and another brood is started on the same litter. Fresh material is added every time the litter becomes too dirty until the litter is 25 to 30 centimeters deep.

given in dry form and, together with fresh drinking water, was made accessible to the birds at all times during the day.

Immediately after hatching, the chicks were legbanded and weighed and then divided equally into two lots. The chicks in each lot were confined for hardening in heated box brooders during their first three days of life, after which they were turned loose into an adjoining concrete pen with litter. The pens assigned to both lots were of the same size, 1.75 m. × 2.45 m., and lay side by side. In the lot I pen in both trials, about twelve centimeters thick of fresh, clean rice hull was placed as litter and was renewed every two weeks. In the lot II pen in trial 1, built-up rice hull litter previously used by one brood of New Hampshire chicks was placed in about the same thickness as in lot I. The same litter was used by lot II chicks in trial 2 with little addition of fresh litter material. The built-up litter was stirred once a week to prevent it from caking, and precautions were taken to keep it dry. Since the pens were inside the building where very limited direct sunlight could penetrate, a sunning yard measuring 1.30 m. × 1.65 m. and floored with a layer of fine seashore sand was provided for each lot.

The chicks in both lots were weighed individually every week. Mortality and its major causes were noted down, as well as the amount of feed consumed.

## RESULTS AND DISCUSSION

*Rate of growth.* The average biweekly gains in weight of the birds clearly indicate the favorable effect of built-up floor litter on growing chicks (table 1). The averages of the two trials show that from the start to the end of the 12-week study, the built-up litter chicks were superior in weight to those in the fresh litter lot. Figure 1 gives the average weights of the chicks at different ages in the two trials.

These results corroborate the findings of Kennard and Chamberlin (1949a) who attributed the better growth rate of the experimental chicks to the presence in the built-up litter of supplemental dietary factors, including the unidentified animal protein or vitamin factor(s) necessary to an all-plant protein diet for chicks. Halbrook, Winter, and Sutton (1950a, b) also reported the growth-promoting influence of built-up litter and identified the factor responsible as vitamin $B_{12}$, which was present in the voided fecal matter of the chicks.

*Mortality.* In spite of the apparently unhygienic condition of the lot with built-up litter, a lower rate of mortality occurred in this lot than in the lot with fresh litter (table 2). Extensive experiments in the Ohio Experiment Station have indicated that the orthodox sanitary practice of frequent removal and renewal of the floor litter is a self-defeating procedure for the prevention and control of diseases, particularly coccidiosis (Kennard and Chamberlin, 1949b).

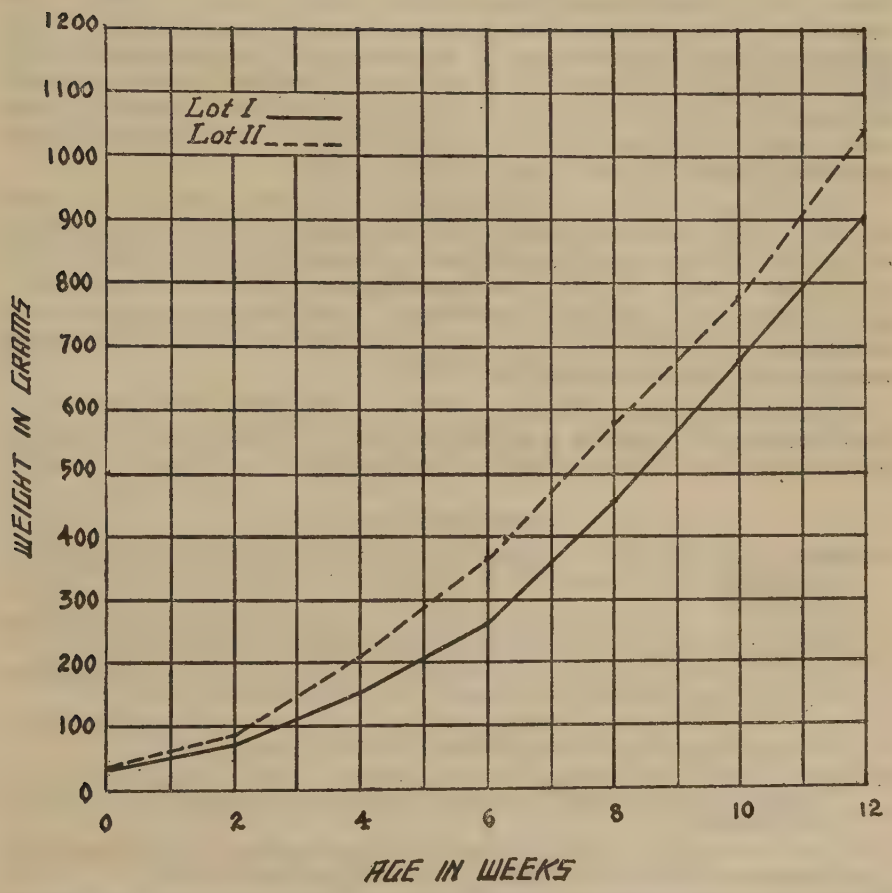



Fig. 1.—Average weights of New Hampshire chicks at different ages in both trials.

Built-up litter is reported by Kennard and Chamberlin (1951) to be a new type of sanitation, or a self-sterilization method; the action of the litter purifies and destroys the harmful bacteria, protozoa, and other disease-producing factors.

Deaths in both lots were mostly attributed to roundworm and coccidial infestations. Though lot I was raised on supposedly parasite-free litter, parasite ova and oocysts were probably introduced from the adjacent pens into the clean litter by flying dust particles. Judging from the losses incurred from parasitic infestations in both lots, the use of built-up litter for growing chicks does not appear to present as dangerous a problem as may normally be expected. There is always the potential danger, however, of ova and oocysts building up in the built-up litter and causing great parasitic damage to the brood (Koutz, 1953).

*Feed consumption.* The difference in the amounts of feed consumed by lot I and lot II birds in the two trials (table 3) is accounted for by the difference in the number of birds that were raised up to the twelfth week. In lot I 56 weanlings survived the observation period, whereas in lot II 61 survived. Also, the greater feed consumption of lot II birds may be partly attributed to the heavier weights they put on during the trials.

As a measure of efficiency of feed utilization, the amount of feed required to produce a kilogram gain in weight was computed. As expected, the chicks raised on built-up litter were more efficient.

LITERATURE CITED

KENNARD, D. C., AND V. D. CHAMBERLIN. 1948. Built-up floor litter a source of dietary factors essential for the growth of chickens. Poul. Sci. 27: 240–243.

———. 1949a. Built-up floor litter sanitation and nutrition. Ohio Agric. Exper. Sta. Farm and Home Research 34: 162–166.

———. 1949b. Growth and mortality of chickens as affected by management of the floor litter. Poul. Sci. 23: 770–771.

———. 1951. Effect of litter on growth and mortality of chickens as affected by the floor litter. Poul. Sci. 30: 47–54.

HALBROOK, E. R., A. R. WINTER, AND T. S. SUTTON. 1950a. The effect of management on the vitamin $B_{12}$ content of poultry house litter. I. Poul. Sci. 29: 672–678.

———. 1950b. The effect of management on the vitamin $B_{12}$ content of poultry house litter. II. Poul. Sci. 29: 679–684.

KOUTZ, F. R. 1953. The effect of built-up litter on the parasite ova and oocysts of poultry. Poul. Sci. 32: 313–320.

TABLE 1

*Average initial and biweekly weights of New Hampshire chicks*

| AGE IN WEEKS | LOT I | | | LOT II | | |
|---|---|---|---|---|---|---|
| | Trial | | Average | Trial | | Average |
| | 1 | 2 | | 1 | 2 | |
| Initial | 32.8 | 38.2 | 35.5 | 33.5 | 38.9 | 36.2 |
| 2 | 72.5 | 84.9 | 78.7 | 80.7 | 101.3 | 91.0 |
| 4 | 130.5 | 177.1 | 153.8 | 174.4 | 230.9 | 202.7 |
| 6 | 265.1 | 278.4 | 271.8 | 374.7 | 374.3 | 374.5 |
| 8 | 455.9 | 478.8 | 467.4 | 570.2 | 602.6 | 586.4 |
| 10 | 658.6 | 716.8 | 687.7 | 733.9 | 831.6 | 782.8 |
| 12 | 858.0 | 943.8 | 900.9 | 964.4 | 1,106.7 | 1,035.6 |

TABLE 2

*Mortality rate*

| ITEM | LOT I | | | LOT II | | |
|---|---|---|---|---|---|---|
| | Trial | | Total | Trial | | Total |
| | 1 | 2 | | 1 | 2 | |
| Number of chicks at start | 50 | 23 | 73 | 50 | 23 | 73 |
| Number of chicks at 12 weeks | 40 | 16 | 56 | 42 | 19 | 61 |
| Number of chicks that died | 10 | 7 | 17 | 8 | 4 | 12 |
| Percentage of mortality | 20.0 | 30.4 | 23.3 | 16.0 | 17.4 | 16.4 |

TABLE 3

*Amount of feed required to produce a kilogram grain in weight*

| ITEM | LOT I | | | LOT II | | |
|---|---|---|---|---|---|---|
| | Trial | | Total | Trial | | Total |
| | 1 | 2 | | 1 | 2 | |
| Amount of feed consumed, kg. | 179.8 | 87.9 | 267.7 | 198.0 | 117.8 | 315.8 |
| Total gain in weight of weanlings at 12 weeks, kg. | 33.0 | 14.7 | 47.7 | 38.9 | 20.3 | 59.2 |
| Amount of feed required to produce a kilogram gain, kg. | 5.45 | 5.91 | 5.61 | 5.09 | 5.80 | 5.34 |

# THE GROWTH AND PERFORMANCE OF ½ HOLSTEIN × ½ RED SINDHI CROSSBRED CATTLE [1]

JOHN M. TAYLOR

WITH TWO TEXT FIGURES

The mean weight of the ½ Holstein × ½ Red Sindhi crossbreds at birth was 19.8 ± 0.80 kilograms, and at the age of one year, 164.3 ± 4.67 kilograms. The correlation coefficients of the different body measurements and weights of the animals at one year of age were as follows: heart girth, 0.754; height of withers, 0.487; length of body, 0.390; width of shoulder, 0.624; and width of hips, 0.782. Since $r = 0.632$, only the values of $r$ for heart girth and width of hips gave significant results. The value of $r$ for width of shoulder was, however, suggestive. The mean age of 11 crossbreds when bred for the first time was 18.5 ± 1.31 months. Two gave birth at the age of 23 months, one at 29 months.

When compared with their Red Sindhi dams, the three milking crossbreds gave higher production records. The highest producer among the dams gave 4.10 liters in one day during her first lactation, whereas among the crossbreds the highest producer gave 12.15 liters in one day. The crossbred heifers showed better size, shape, and placement of teats than the Red Sindhi heifers. The milking crossbreds were easier to milk and were less vicious than the Red Sindhi cows.

The improvement of cattle in the Philippines through the introduction of high milk producing western breeds like the Holstein, Jersey, and Ayrshire have failed because the animals are not adapted to our tropical climate. Indian cattle have shown good adaptability to Philippine conditions, but they are, at best, dual-purpose types and can not be expected to be good milkers.

According to Guzder (1952), Henderson noted that first-cross animals of European Ayrshire and Indian were good, but that subsequent crosses from matings *inter se* turned out to be poor milkers and lacked uniformity of type. Henderson added that back-crossing to the indigenous (Sahiwal) sire produced better results in the ¾ Sahiwal × ¼ Ayrshire offspring. Guzder (1952) further stated that Forman obtained a superior product when the Holstein-Friesian breed was used in place of the Ayrshire.

Mating the Holstein with the Red Sindhi is expected to result in an offspring that will be both productive in milk and adapted to Philippine conditions. Since the aim of such a crossbreeding experiment is to see whether a commercially profitable type of dairy cattle can be formed, observations were made on the growth and development of Holstein × Red Sindhi first-generation heifers, the age when the animals started to nibble on concentrates and soilage, the

[1] Central Experiment Station Contribution No. 1732. Thesis presented for graduation with the degree of Bachelor of Science in Agriculture from the College of Agriculture, October, 1953. Prepared in the Department of Animal Husbandry under the direction of Mr. Leopoldo S. Castillo.

age when the horns broke through the skin, the development of the udder, the ages at first breeding and calving, the milk production at the first lactation, and the color at maturity. The results reported in this paper cover the data for the first of a series of studies. The work was carried out in the Department of Animal Husbandry from July 30, 1952, to September 15, 1953.

## MATERIALS AND METHODS

Thirteen Holstein × Red Sindhi first-generation crossbred females sired by Hardie, a purebred Holstein bull, were used in the study. At the beginning of the observation, their ages ranged from birth to 84 weeks. Newborn calves were weaned completely from their mothers immediately after birth and taught to drink from the pail. The amount of milk given each calf was approximately ten per cent of its live weight. Feeding was done in the morning at about nine o'clock and in the afternoon at about three o'clock after the regular milking chores were over. After feeding, the calves were placed in pens provided with feeding stalls where concentrates, soilage, and water were available. The calves were also allowed to go to pasture to give them the benefit of sunshine. At night, they were again confined in the pens. In all other respects, they were given the same management as that given the dairy calves of the College, such as removal of the umbilical cord and painting with tincture of iodine, ear-notching for identification purposes, and medical treatment for scours and stomach worms.

The older animals were on pasture the greater part of the time. They were led into the barn once a day, at about ten o'clock in the morning, to receive their daily concentrate rations. The milking crossbreds were managed similarly as the milking cows of other breeds, that is, they were brought into the barn from the pasture at about four o'clock in the morning and placed at the stanchions where they were milked and fed concentrates. After milking and after they had consumed their rations, they were led out to pasture again. This was repeated in the afternoon at about two o'clock.

The weights and measurements of the animals were taken at birth and at intervals of four weeks thereafter for 52 weeks. The animals were made to stand squarely on their legs on the concrete barn floor. The height was determined by measuring the perpendicular distance from the floor to the top of the withers. The heart girth was determined by measuring the circumference of the chest just behind the shoulders. The length of body was determined by measuring the distance between the pinbone and the point of shoulder with a wooden caliper. The hindquarters between the points of the hips and the forequarters between the points of the shoulders were measured for the width of hips and shoulders, respectively.

The ages of the animals when they began to nibble on concentrates and soilage, when their horns first broke through the skin, and

when they mated and calved were noted with the cooperation of the herdsman and milker who took care of the animals most of the time during the day.

## RESULTS AND DISCUSSION

*Growth.* The ½ Holstein × ½ Red Sindhi heifers had a mean birth weight of 19.8 ± 0.8 kilograms. They were slightly lighter than the Red Sindhi heifer calves of the College herd which had a mean birth weight of 22.9 ± 0.8 kilograms. Villegas (1939) observed that female Red Sindhi calves in the College had a mean birth weight of 24.60 ± 0.77 kilograms. Henderson, Larson, and Putney (1947) reported that the birth weight of Holstein females in Missouri was 40.9 kilograms. The average birth weight, however, of two Holstein female calves in the College was only 23.0 kilograms, which is approximately one-half of that reported in the United States though slightly heavier than the birth weight of the crossbreds.

At the age of one year, the crossbreds weighed 164.3 ± 4.67 kilograms, and the Red Sindhi heifers of the College dairy herd weighed 98.0 ± 6.37 kilograms. The average weight of three Holstein heifers in the College at the age of one year was 198.3 kilograms. The heart girth of the crossbreds at one year of age measured 130.5 ± 1.17 centimeters; the height at withers, 102.4 ± 0.94 centimeters; the width of shoulders, 30.3 ± 0.45 centimeters; the width of hips, 30.8 ± 0.31 centimeters; and the length of body, 98.7 ± 0.66 centimeters.

The correlation coefficients, $r$, of the different body measurements and weights of 10 animals were computed at the end of 52 weeks. The values of $r$ were as follows: heart girth, 0.754; height of withers, 0.487; length of body, 0.390; width of shoulders, 0.624; and width of hips, 0.782. Since $r = 0.632$, then for a probability of 5 per cent at 8 degrees of error for significance, only the values of $r$ for heart girth and width of hips gave significant results (rejecting the null hypothesis that $p = 0$). The value of $r$ for width of shoulders was, however, suggestive.

Misner (1941), working on 100 cows of the major dairy breeds in Cornell, placed the following higher correlation values for body measurements: heart girth, 0.97; length of body, 0.89; and width of hips, 0.92. It should be remembered, however, that the age and breed of the animals studied here differ from those studied by Misner.

*Ages at first breeding and calving.* The mean age of 11 crossbreds when bred successfully for the first time was 18.5 ± 1.41 months. Two crossbreds gave birth at the age of 23 months, and one gave birth at the age of 29 months. If the gestation period of cattle is 9½ months, the estimated age of the animals at their first parturition would be an average of 29 months. Rigor (1949) ob-

served that the average age of Red Sindhi cattle in Alabang at first fertile mating was 27½ months, and the average age at first calving, 36½ months. Stonaker, Agarwala, and Sundaresan (1953), working on the dairy cattle of the Gangetic plains of India, gave the weighted average at first calving of ½ Jersey × ½ Red Sindhi as 29 months and that of its check group of pure Red Sindhi as 41 months. They further reported that ¼ and ⅛ Jerseys gave their first calves at 36 and 39 months, respectively, and their corresponding check groups of Red Sindhi, at 40 and 43 months. On this point, the ½ Holstein × ½ Red Sindhi crossbreds agree closely with their ½ Jersey × ½ Red Sindhi counterparts. Early calving is a desirable trait because the animals give milk without too much delay.

*Milk production.* The milk production records of the dams of the three milking crossbreds were compared with those of their daughters. Red Sindhi cow No. 6 gave 24.40 liters in 46 days lactation period, or an average of 0.53 liter daily; cow No. 7, 11.85 liters in 34 days lactation period, or an average of 0.35 liter daily; and cow No. 10, 924.75 liters in 288 days lactation period, or an average of 3.21 liters daily. The highest production of cow No. 10 was 4.10 liters in one day during the third month of milking.

The very short lactation periods as well as the incredibly low milk productions of Red Sindhi cows No. 6 and 7 may be attributed to the practice then employed of preventing the calves from sucking their mothers prior to milking. It might be interesting to mention that in the second lactation period of these two cows, their calves were allowed to suck them to stimulate milk flow. Production rose to 146.3 liters in 195 days for cow No. 6, or an average of 0.75 liter a day, and to 198.95 liters in 289 days for cow No. 7, or an average of 0.69 liter daily. Red Sindhi cow No. 10 was one of the few animals of the breed which did not respond adversely to the practice of not allowing the calves to suck their dams. No butterfat and specific gravity tests were made of the milk produced at the time (1948-1949).

Guzder (1952) reported that the milk yield of the Red Sindhi cows in the Allahabad Agricultural Institute, India, was 2102.8 pounds (955.8 kilograms) in 239 days, 2156.2 pounds (980.1 kilograms) in 262 days, and 2236.3 pounds (1016.5 kilograms) in 231 days in the first, second, and third lactations, respectively.

The Holsteins of the College, at their first lactation, gave an average of 2065.19 liters (2127.15 kilograms) in 305 days of lactation, or an average daily production of 6.77 liters, with a butterfat test of 3.40 per cent. In the United States, Eckles and Anthony (1950) put the average production of this breed for the same period at 8500 pounds (3863.6 kilograms), with 3.45 per cent butterfat test, under ordinary farm conditions and good management.

Only crossbred cow No. 5 completed the 305 days of lactation on which milk production in one lactation was based. Her produc-

tion was 1429.63 liters (1472.5 kilograms) of milk, or an average daily production of 4.69 liters. Crossbred cows No. 9 and 4 had incomplete milk production. The first gave 518.81 liters (534.4 kilograms) in 165 days of lactation, with an estimated average daily production of 3.14 liters; the second, 1599.15 liters (1647.1 kilograms) in 150 days of lactation, or an estimated average daily production of 10.66 liters. The weighted average of the butterfat tests of these three animals was 4.15 per cent, and that of the specific gravity of the milk, 1.030. The highest production of No. 5 crossbred was 6.50 liters (6.7 kilograms) on the thirty-second day of lactation, whereas crossbred No. 9 gave 4.28 liters (4.4 kilograms) on her twenty-fifth day. Crossbred No. 4 (fig. 1) gave the highest produc-

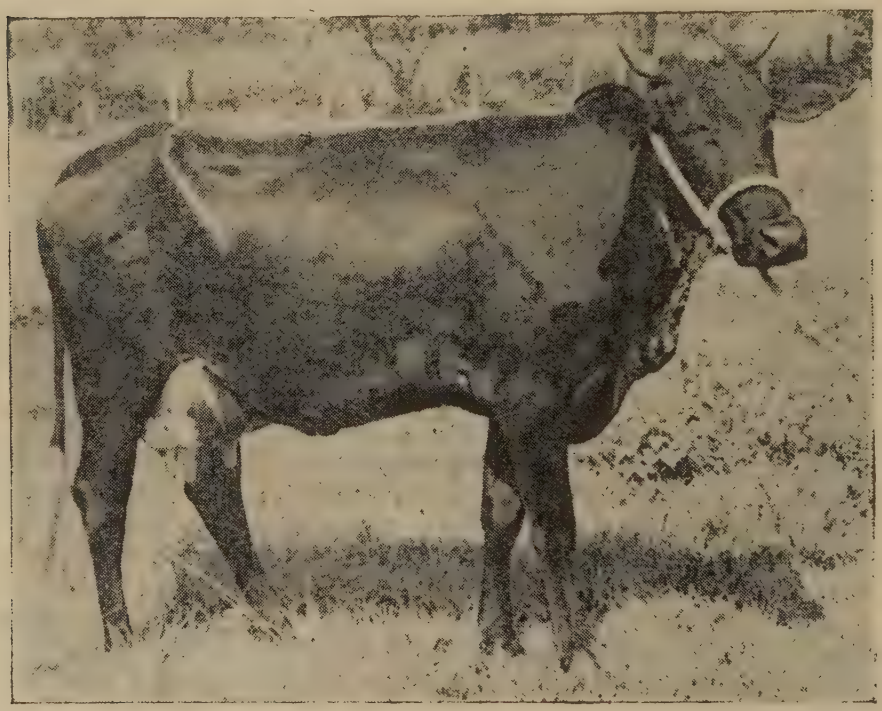


Fig. 1.—Cow No. 4, the ½ Holstein × ½ Red Sindhi which gave the highest milk production of 12.15 liters in one day.

tion of 12.15 liters (12.5 kilograms) on the twenty-seventh day of lactation.

The correction factors given by Cannon, Frye, and Sims and cited by Espe (1948) were used to estimate the production of crossbreds No. 9 and 4 in 305 days. It was estimated that crossbred No. 9 would produce 793.78 liters (817.5 kilograms), and crossbred No. 4, 2623.60 liters (2702.3 kilograms), clearly showing that the crossbreds gave more milk than their dams. These findings corro-

borate the conclusion of Stonaker *et al.* (1953) that the crosses not only give more milk than the purebred Red Sindhi, but also begin their productive lives earlier.

*Udder and milking characteristics.* Unbred heifers showed better size, shape, and placement of teats than the Red Sindhi heifers. The teats of most of the Red Sindhi cows in the herd were large at

Fig. 2.—A close-up of the udder of cow No. 4.

the base; those of the crossbreds, on the other hand, had uniform development. Unlike the teats of most of the Red Sindhi cows, those of the three milking crossbreds were firm (fig. 2). One of the crossbreds, however, had a weak sphincter muscle in the left rear teat so that milk dripped in the morning when the udder was full.

The crossbreds were easy milkers, like the Holsteins. Many Red Sindhis held up their milk unless first stimulated by their calves. Only crossbred No. 9 had the bad habit of kicking.

*Color.* At birth the crossbreds were dark red, resembling the Red Sindhi parent. As they grew older, they turned darker brown, some closely approaching black. A few had white spots under the neck and splashes of white on the underline. One crossbred could easily be mistaken for a Holstein. Three had white switches; the others had black. There was no definite color pattern. Guzder (1952) reported that one of the reasons why crossbreeding work using the Holstein was discontinued was that the Holstein-Red Sindhi crosses did not blend with the red colors of the Red Sindhi. Stonaker (1952) suggests that for less color variation, red and white Holstein bulls be used.

*Ages at first nibbling and appearance of horns.* The age when seven calves began to nibble on concentrates was, on the average, 7 weeks, with a range of 5 to 9 weeks.

The horns broke through the skin from 10 weeks and 2 days to 17 weeks and 4 days after birth, or an average of 13 weeks and 3½ days.

LITERATURE CITED

ECKLES, C. H., AND E. L. ANTHONY. 1950. Dairy cattle and milk production. 4th ed., xvi + 560 p., 101 fig. New York: MacMillan Company.

ESPE, D. 1948. Secretion of milk. 3rd ed., viii + 320 p., 61 fig. Iowa: Iowa State College Press.

GUZDER, P. J. 1952. The Brown Swiss cross with Indian cattle. Allahabad Farmer 25: 191–201.

HENDERSON, H. O., C. W. LARSON, AND F. S. PUTNEY. 1947. Dairy cattle feeding and management. 3rd ed., xxvi + 557 p., 108 fig. New York: John Wiley & Sons, Inc.

MISNER, H. E. 1951. Measurements and weights of one hundred cows in the Cornell dairy herd. Cornell Univ. Agric. Exper. Sta. Bull. 771: 1–21.

RIGOR, T. V. 1949. Observations on Red Sindhi cattle: I. The breeding activities. Philippine Jour. Anim. Indus. 10: 143–147.

STONAKER, H. H. 1952. Plans for genetic increases in productivity of Indian cattle. Allahabad Farmer 25: 183–190.

————, C. P. AGARWALA, AND D. SUNDARESAN. 1953. Production characteristics of crossbred, backcross, and purebred Red Sindhi cattle in the Gangetic Plains region. Jour. Dairy Sci. 36: 678–687.

VILLEGAS, V. V. 1939. The birth weight of horses, cattle, and carabao, and their relation to the weight of dam. Philippine Agriculturist 28: 283–259.

# ADDITIONAL DATA ON THE BREEDING HABITS OF RED SINDHI CATTLE [1]

LINO E. NAZARENO

WITH THREE TEXT FIGURES

The average interval between calving and the following oestrus in the Red Sindhi cows studied was 158.2 ± 23.7 days. The most common symptoms of oestrus were (a) approaching of the bull, (b) raising of the tail and simultaneous arching of the back, (c) vaginal discharge of mucus, (d) frequent urination in small amounts, (e) restlessness, and (f) mounting of other cattle. The cow in oestrus had congested and dark-red mucosa and discharged thin, watery mucus from a somewhat relaxed cervix. The oestrus period averaged 13.4 ± 0.8 hours. The next oestrus appeared after a weighted average of 21.3 ± 1.2 days.

The cows at mating time manifested (a) restlessness, (b) frequent urination in small amounts, (c) bending of the lumbo-sacral articulation when the bull licked the vulva, (d) persistent arching of the back and raising of the tail, and (e) ready acceptance of the bull. The bulls showed the following behavior: (a) approaching and chasing of the cow in oestrus, (b) smelling and licking of the vulva of the cow, (c) raising of the head and eversion of the upper lip, (d) pause before protrusion of the penis, (e) protrusion of the penis, (f) passing of droplets of urine from erect penis before mounting and coition, (g) frequent passing of small amounts of watery feces, and (h) driving of non-oestrus cows.

The symptoms of pregnancy that were generally recognized were (a) cessation of heat periods, (b) increased size, (c) tendency to become quiet, (d) tendency to lay on fat, (e) enlargement of the mammary glands particularly in the later part of pregnancy, and (f) presence of pale-pink and closed cervix. Generally, the cows manifested the following signs of impending parturition: (a) general nervousness and fickle appetite, (b) repeated emission of slimy vaginal discharges, (c) distinct enlargement of the teats and udder, and (d) loosening of the ligaments and muscles in the pelvic region.

The average length of gestation of three cows was 285.3 ± 0.9 days. Labor pains lasted for an average of 1 hour and 18 minutes. The placenta or afterbirth was dropped after an average of 3 hours and 3.7 minutes after expulsion of the fetus. The cows evidenced a marked change in disposition immediately after parturition.

For additional information on the breeding habits of Red Sindhi cattle, a study was carried out in the Department of Animal Husbandry of the College of Agriculture at Los Baños from November, 1951, to January, 1953. The interval between calving and following oestrus, signs and duration of oestrus, interval between oestruses, behavior of the cow and the bull at mating time, signs of pregnancy, signs of coming parturition, period of gestation, and behavior of cow and calf during and immediately after calving were observed.

[1] Central Experiment Station Contribution No. 1733. Thesis presented for graduation with the degree of Bachelor of Science in Agriculture from the College of Agriculture, April, 1953. Prepared in the Department of Animal Husbandry under the direction of Mr. Leopoldo S. Castillo.

Sarao and Manresa (1941) stated that the average gestation period in Red Sindhi cattle is 287 days and that the average time between calvings is 345 days. The lactation period ranges from 219 to 397 days, or an average of 345.

VanDemark and Salisbury (1950) opined that an interval of 12 to 13 months between calves usually is satisfactory. Studies by Gaines and Palfrey (1931) and Chapman and Casida (1935) showed that cows calving every 12 months or less had higher milk yields a day during the interval between calves than those that reproduced after more than 12 months.

According to Rice (1942) cows may come in oestrus from 16 to 90 days after calving, although the usual period is from 40 to 50 days. Afterwards oestrus recurs at intervals of 19 or 20 days. Manresa and Diapo (1938) found that the average duration of oestrus cycle is 20 days. Perry, Bartlett, Taylor, Edwards, Terrill, Berliner, and Jeffrey (1945) reported the duration of the oestrus cycle to be from 19 to 23 days, with 20 days as the average.

Manresa and Diapo (1938) pointed out that the duration of heat in cows is from 12 to 24 hours. Rice and Andrews' (1951) estimation of the duration of oestrus in cattle was from 8 to 30 hours, with an average of 16 to 20 hours. Perry, Bartlett, Taylor, Edwards, Terrill, Berliner, and Jeffrey (1945) stated that the duration of oestrus in cows is from 6 to 30 hours, or an average of 19 hours. According to Kelly (1946), oestrus usually lasts from 12 to 18 hours.

Perry, Bartlett, Taylor, Edwards, Terrill, Berliner, and Jeffrey (1945) stated that in a normal cow, the cervix opens slightly during oestrus. In normal mating the penis of the bull does not penetrate the cervix; the semen is deposited in the vagina close to the entrance. They further stated that the most fertile semen usually comes from bulls that are not overworked.

Manresa and Diapo (1938) summarized the signs of pregnancy as follows: (a) improvement of the condition of the animal as early as the fifth month of pregnancy and as late as the eighth month; (b) enlargement of the abdomen, which becomes quite marked from the sixth to the eighth month of pregnancy; (c) swelling of the external genitals; (d) enlargement of the mammary glands, which occurs early in heifers, but not until a few days before parturition in older cows; (e) drooping of the rump in the later stages of pregnancy; (f) sagging of the back as early as the sixth month and as late as the ninth; and (g) appearance of a ropy mucoid discharge from the vulvar orifice as early as the fifth month or, sometimes, just a few days before parturition. Rice's (1942) findings on the signs of pregnancy follow: (a) cessation of heat period; (b) formation of the characteristic adhesive uterine seal in the cervix; (c) presence of firm, tense, and fluctuating uterus as determined by palpation through the rectum; (d) increased size of abdomen; (e) detection of fetal heart by auscultation; (f) movements of the fetus;

and (g) general tendency to become quiet and lay on flesh. Clamohoy (1952) noted the following signs of pregnancy: (a) pale-pink and closed cervix; (b) sticky vaginal mucus and pale-pink vaginal mucous membrane; and (c) passing out of mucus as early as 30 days before parturition.

On the approach of parturition, Manresa and Diapo (1938) found that the external genitals and udder of the cow became greatly distended from the sixteenth to the third day before calving. The symptoms most regularly observed at the initiation of parturition were further depression of the rump, distention of the mammary glands and the surrounding parts, and marked swelling of the external genitals. Rice (1942) noted that the ligaments and muscles in the pelvic region loosened just before parturition, the tail was raised, the flanks and rump became hollow, and the enlarged abdomen dropped. Most of the cows bellowed, were nervous, and had changeable appetites. The movement of the fetus was discernible to the touch. Clamohoy (1952) observed intermittent vaginal mucus discharge beginning about fifteen days before delivery, swelling of the vulva and udder 8 to 12 days before parturition, deep depression of the rump and base of tail 2 days before delivery, and deep sagging of the abdomen and back a few hours before parturition.

## MATERIALS AND METHODS

*Breeds and ages of animals.* Sixteen Red Sindhi cows, one breeding Red Sindhi bull, and one vasectomized Red Sindhi bull were used. Two Holstein-Freisian bulls were bred to the Red Sindhi cows to produce Holstein-Freisian-Red Sindhi crosses. The behavior of these bulls at mating, however, was not observed.

The cows ranged in age from about three and one-half years to twelve years, the average being six and one-half years. Herd No. 18, the breeding bull (fig. 1), was five years old, and Herd No. 34, the vasectomized bull, was three and one-half years old.

*Management of the animals.* The animals were tethered individually in the pastures of the dairy compound. Six pastures were provided for rotation purposes. The animals were driven to the stanchions early in the morning, fed concentrates, and watered. Milking was done two times a day for the high producers and once for the low producers. A month before the expected parturition, milking of a pregnant cow was stopped. The cows which gave birth were separated from the dry herd.

*Observations on breeding habits.* The animals were observed daily. The length of coital period in an oestrus was determined by allowing the bull to stay with the cow until two or three days before the expected recurrence of oestrus. The first time the cow permitted coition was considered the onset of the coital period in the oestrus, and the last coition, after which the cow persistently refused to receive the bull, was taken as the end of the period.

Oestrus and the interval between oestruses were determined with the use of the vasectomized bull. Since the vasectomized bull was sterile, natural mating took place, but not fertilization. The number of days between first mating during an oestrus and the first mating during the following oestrus was taken as the interval between oestruses.

The cows were weighed twice a week from the time of mating with the breeding bulls. The circumferences of the barrels of the pregnant cows were measured. Observations on the color and position of the cervix and consistency of the vaginal mucus of pregnant cows were made with a vaginal speculum once a month, immediately followed by palpation of the fetus through the rectum.

The semen of Herds No. 18 and 34 was collected with an artificial vagina and examined for sperms.

## RESULTS AND DISCUSSION

### *Interval between calving and the following oestrus*

The average interval between calving and the first appearance of oestrus (table 1) was 50.2 days longer than that reported by Manresa and Diapo (1938) and 42.1 days longer than the average of 116.1 days reported by Clamohoy (1952).

### *Signs of oestrus*

The most common symptoms of oestrus observed were (a) approaching of the bull, (b) raising of the tail and simultaneous arching of the back, (c) vaginal discharge of mucus, (d) frequent discharge of urine in small amounts, (e) restlessness, and (f) mounting of other cattle. Swelling of the vulva as reported by Clamohoy (1952) and Rice and Andrews (1951) was not a common occurrence among the cows in heat. Only two cows, Herd No. 1 and Herd No. 11, showed marked swelling; slight swelling was noted in three cows, namely, Herds No. 9, 8, and 3. This observation substantiates the opinion of Manresa (1931) that the swelling of the vulva may not be accompanied by a ripe follicle or corpus luteum and, therefore, does not necessarily indicate the occurrence of oestrus.

Upon examination, several of the cows showed congested vaginal mucosa during the oestrous period. The vaginal mucosa was dark red in seven cows, rosette in three cows, and pale in one cow. This agrees with Manresa and Diapo's (1938) statement that the dark-red coloration of the vaginal mucosa, if accompanied by other symptoms of oestrus, is a very good sign that mating will occur.

Further examination revealed that the mucus secreted from the cervices of the cows appeared thin and watery and that the cervices were somewhat relaxed.

### *Duration of oestrus*

The average duration of oestrus in the Red Sindhi cows which were mated (table 2) is close to Clamohoy's (1952) finding of 15.4

hours for grade Sindhi cows. When service was withheld, Herd No. 13 and Herd No. 10 were in heat longer than when service was allowed soon after oestrus was detected. In these two cows oestrus lasted for 22.0 and 23.0 hours, respectively.

*Interval between oestruses*

The average recurrence of oestrus among nine cows that were not impregnated (table 3) is close to Manresa and Diapo's (1938) average of 20 days. Rice and Andrews (1951) gave a range of 16 to 24 days, or an average interval of 20.4 days.

Herd No. 8 had irregular intervals between oestruses probably because of physiological causes. One cow, Herd No. 11 (fig. 2), underwent five oestrous periods although she was bred on her third and on her fourth oestrus by a Holstein-Freisian bull. She was fertilized on her fifth oestrus by the Red Sindhi bull.

*Behavior of the animals at mating*

*Cows.* The usual behavior observed among the different cows consisted of the following: (a) restlessness, (b) frequent urination in small amounts, (c) bending of the loin (lumbo-sacral articulation) when the bull licked the vulva, (d) persistent arching of the back and raising of the tail throughout mating, and (e) ready acceptance of the bull. Running during coition, mounting other cattle irrespective of sex or age, rubbing against and licking the body of the bull, approaching the bull, intermittent grunting and grazing during coition, and smelling the sheath of the bull before and after coition, followed by raising of the head and eversion of the upper lip, were infrequently noticed. Convulsive movements of the muscles between the anus and vulva, butting of the bull, and jumping in a playful manner while in association with the bull were observed in a few cows.

*Bulls.* The following manifestations observed by Clamohoy (1952) were also noted in the two Red Sindhi bulls used in this study: (a) approaching and chasing of the female in oestrus, (b) smelling and licking of the vulva of the cows, (c) raising of the head and eversion of the upper lip, (d) pause before protrusion of the penis, (e) protrusion of the penis, (f) passing of droplets of urine from erect penis before mounting and coition, (g) frequent passing of small amounts of watery feces, and (h) driving of non-oestrous cows. Intermittent grunting and grazing during mating and stretching of the tail prior to mounting were as frequently manifested by the bulls as by the cows.

*Coitive capacity of the bulls*

*Frequency.* The number of coitions that the Red Sindhi bull, Herd No. 18, effected during an oestrous period of a cow ranged from two to four. Never did the bull accomplish more than four services. Sometimes the bull still had the desire to mate, but the

cow persistently refused any more service. The frequency of coition was especially affected by the physical condition of the bull. From March to the later part of April, the bull usually made only two services to any of the cows in oestrus within that period. This may be attributed to the poor condition of the bull, possibly because of the insufficient supply of green feeds and/or the weather. The animals depended mostly on silage and concentrates, the pastures being severely denuded.

*Semen.* Attempts to collect semen with the use of the artificial vagina failed mainly because each of the bulls persistently refused to ejaculate as soon as the erect penis was thrust into the artificial vagina. This difficulty arose because the bulls were not so trained. The features of the semen, therefore, were not completely studied. Semen for fertility examination was collected by the simplest method; it was collected from the floor of the vagina afer copulation. The semen of the breeding bull, Herd No. 18, had sperms which showed rapid, progressive, and vibrating movement, but that of the vasectomized bull, Herd No. 34, was free from sperms. Herd No. 18 was undoubtedly fertile since his semen had normal, viable sperms, aside from the fact that he had sired a number of the College Red Sindhi cattle.

*Signs of pregnancy*

The cessation of the heat period or oestrus was a definite sign that the animal was impregnated. This was indicated by observations made on three cows, Herds No. 13, 1, and 4, which delivered their calves on October 2, 1952, December 24, 1952, and January 3, 1953, respectively. These animals, after being served by the breeding bull, did not come in heat again, confirming Rice and Andrews' (1951) report that the cessation of heat periods is nature's first indication that conception has occurred. These authors explained that pregnant animals fail to come in oestrus because of the persistence of the corpus luteum of pregnancy and the inhibition of follicular development.

Increased size and the tendency to become quiet and to grow fat were also distinct signs. Herds No. 13, 1, and 4 weighed 276, 358, and 252 kilograms, respectively, during the first week of impregnation and 304, 400, and 288 kilograms, respectively, during the week of expected parturition. The average increase in weight during pregnancy was 35.3 kilograms.

The circumference of the barrel of Herd No. 13 during the first week of pregnancy was 183.4 centimeters; that of Herd No. 1 was 201.5 centimeters. During the week of expected parturition the barrel of Herd No. 13 increased by 29 centimeters, and that of Herd No. 1 increased by 24 centimeters. Since Herd No. 4 was in poor condition, she was removed from the dairy herd on the fourth month of gestation.

Enlargement of the mammary glands was another sign of pregnancy commonly noted. The mammary glands of the three cows earlier referred to were not swollen during the early and middle stages of pregnancy; towards the later part of pregnancy, however, they enlarged to a marked degree. In Herd No. 27, distinct swelling of the mammary glands was noticed 26 days before parturition; in Herd No. 31, slight enlargement was apparent 65 days before parturition.

The cervices of Herds No. 13, 1, and 4 were pale pink throughout the gestation period. The cervical mucus became very thick and formed a more or less permanent plug that sealed the cervix, apparently to protect the developing embryo. The cervix was always tightly contracted and its os uteri closed.

To ascertain the definite occurrence of conception, a manual examination or palpation of the fetus through the rectum was made monthly. The fetus of Herd No. 13 was felt as early as the beginning of the third month, whereas the fetuses of Herds No. 1 and 4 were felt at the beginning of the fourth month after impregnation.

*Signs of coming parturition*

All parturient animals gave evidence of approaching parturition by their general nervousness and fickle appetites; Herd No. 27 extruded a slimy vaginal discharge for the first time 29 days prior to parturition; Herd No. 3 did not expel any discharge except immediately before delivery. It may be inferred, therefore, that the emitting of vaginal discharges is not a definite and specific sign of immediate parturition. The phenomenon, however, is a good warning. In all the cows the teats and udder were distinctly enlarged three or two weeks before delivery.

The animals generally evidenced loosening of the ligaments and muscles in the pelvic region just before parturition. The pelvic region relaxed, the tail rose, the flanks became hollow, and the enlarged abdomen dropped. On the approach of parturition, movements of the fetus were often shown by the movement of the flanks, and the fetus was recognizable by touch. These observations corroborate those of Rice and Andrews (1951).

It was also noted in the present study that when a depression appeared on each side of the sacrum at the base of the tail, the cow generally dropped her calf within a few days. The depression of the rump and the deepening of the lumbo-sacral articulation usually appeared at about the same time.

*Period of gestation*

Only three cows were bred in time for inclusion in the study so that the number of cows observed for length of gestation was limited. Herd No. 13, which was bred on December 23, 1951, delivered her calf on October 2, 1952, or after 284 days; Herd No. 1, which was bred on March 15, 1952, delivered her young on December 24, 1952,

or after 285 days; and Herd No. 4, which was impregnated on March 23, 1952, delivered on January 3, 1953, or after 287 days. The average length of gestation obtained in this study was 285.3 ± 0.9 days, which is slightly shorter than the 287 days reported by Sarao and Manresa (1941) for Red Sindhi cows and five days longer than the average of 280 days for the same breed reported by Rigor (1949).

*Behavior of cow and calf during and immediately after calving*

The teats of Herds No. 27, 31, 3, 32, and 13 filled out to the tips. Milk escaped in drops from Herds No. 3, 13, and 31. These symptoms of parturition are considered reliable by Manresa and Diapo (1938) inasmuch as the young are born within 24 hours after wax forms on the teats.

As parturition drew close, the fetal movements were distinctly observed on the sides of the abdomens of Herds No. 27, 31, 3, 32, and 13. The onset of labor pains was reliably indicated by the cows' uneasiness, switching of the tail, lying down and then rising, and persistent grunting.

In Herd No. 27 labor pains notably set in at 3:00 o'clock a.m. Her increasing restlessness and nervousness were evident signs of pain. A copious amount of liquid was discharged when the allantoic membrane burst at 3:45 o'clock a.m. The cow managed to get up; then she licked the fluid and ate the tissues. Shortly afterwards the forelegs of the fetus appeared. The cow curved her back and stretched her spread-out hind legs in an effort to expel the fetus. Soon afterwards, the forelegs of the young were out up to the knees.

The cow stood up and relaxed. In a couple of minutes she lay down again, and within eight minutes the fetus was expelled. The calf was delivered at 4:08 o'clock a.m., or 1 hour and 8 minutes after labor pains became evident. In Herd No. 31 delivery ensued 1 hour and 18 minutes after labor pains began; in Herd No. 32, it took place after 1 hour and 28 minutes. These observations confirm Rice and Andrews' (1951) statement that labor pains set in from one to a few hours before final expulsion of the fetus. The tempo, duration, and strength of the labor pains were gradually accelerated.

The external genitals of Herd No. 27 appeared greatly reduced in size and showed bloodstains. The sacrum was very conspicuous and gaunt. The coccygeus and the muscles on both sides of the sacrum became more depressed. The pinbones also became prominent. The lumbo-sacral articulation was further depressed. Only Herd No. 27 showed bloodstains after delivery, but the rest of the manifestations were noted in all the cows that delivered. These findings agree with Manresa and Diapo's (1938) observations.

After expelling her fetus, Herd No. 27 rested for a few minutes; then she stood up and licked the body of the newly born calf all over (fig. 1). While doing this, she swallowed the cut navel cord and other fetal membranes of the calf.

Fig. 1.—The newly born calf of Herd No. 27 being licked by its mother. (*Photographed by the Photographic Division, College of Agriculture*).

The calf lay flat on one side with its legs stretched out. Soon after expulsion, the calf was already seen to be breathing even while it was still inside the fetal membrane. The head was the first part of the body to move when it tried to rise. The calf made an attempt to stand up at 4:37 o'clock a.m., or 29 minutes after expulsion. The dam helped her calf by raising it lightly with her muscle (fig. 2). All the other dams showed similar behavior.

Immediately after standing, the calf instinctively looked for the udder of the dam which it located after a very long time. Every now and then, it licked different parts of its mother's body (fig. 3), starting from the brisket to the foreflanks and then to the hindquarters It was able to suck the teats at 6:22 o'clock a.m., or 2 hours and 14 minutes after expulsion. The calf of Herd No. 32 was on its feet 1 hour and 35 minutes after delivery and was sucking 2 hours and 34 minutes after delivery; the sucking lasted for 24 minutes.

Fig. 2.—The first attempt of the calf to stand. To help it the dam raises it lightly with her muzzle. (*Photographed by the Photographic Division, College of Agriculture*).

Fig. 3.—The calf is on its feet for the first time. Note the mother supporting the calf with her muzzle. Note also a part of the afterbirth coming out of the dam's vulva. (*Photographed by the Photographic Division, College of Agriculture*).

Herd No. 31 had to be helped on account of abnormal delivery. She was thought ready to deliver on the morning of June 14, 1952. Her back sagged very much, her barrel was enlarged, her vulva was greatly swollen, and her teats and udder were distended.

At 1:07 o'clock p.m. when the cow was brought to her stall, she began to feel restless; she walked about, grunted repeatedly, and occasionally tried to expel the fetus. Eight minutes later the animal lay down. She stretched her hind legs, then grunted intermittently and raised her head.

The forelegs of the calf were first seen at 1:37 o'clock p.m. An abundant mucous discharge flowed freely from the vagina; the allantoic membrane burst simultaneously. When the forelegs were barely out, the vagina expanded and protruded to its fullest extent. The pelvis too was expanded. The rump was drawn in deeper and the udder was distended a little more. The anus was drawn in while the abdomen dropped; the back sagged. Fetal movements were observed on the sides of the abdomen of the cow. The back was then curved upward and the hind legs were stretched and drawn farther apart, possibly to facilitate expulsion of the fetus.

At 1:50 o'clock p.m. the parturient animal stood up again and the already exposed forelegs of the calf were retracted. When this happened, the vaginal orifice was fully seen and its walls were noticed to be deep pink. The cow remained standing for a minute; then she lay down again on her other side. She was extraordinarily restless by this time.

Shortly thereafter, the cow again attempted to stand up but failed. The pair of legs came out of the vagina anew. With great effort the cow stood up, but only for a minute because she was thrown down, possibly by her own weight or by dire exhaustion. In a short while, the muzzle of the calf was seen with tongue sticking out. The cow pulled up and strained hard to expel the fetus; however, she failed. The College veterinarian was then called. The fetus was pulled out carefully and at 2:25 o'clock p.m. the cow was finally delivered of her calf. It was too big for the cow, hence the difficulty in expelling it.

The calf was helped to its feet within 20 minutes after delivery, and it was able to suck the teats of its mother in 3 hours and 53 minutes, much later than did the calves of Herd No. 27 and Herd No. 32.

Herd No. 1, a 12-year-old cow, also had an abnormal presentation. Her male calf had retained neck and head, causing her to labor for 20 hours without success. The College veterinarian removed the dead calf to save the dam.

The dropping of the placenta or afterbirth varied in the different cows observed. Herd No. 27 dropped her afterbirth 2 hours and 8 minutes after expulsion of the fetus, Herd No. 31 in 4 hours and

4 minutes, and Herd No. 3 in 2 hours and 59 minutes; the average was 3 hours and 3.7 minutes.

Immediately after parturition, all the cows evidenced a marked change in disposition. For instance. attempts to go near the calf of Herd No. 27 failed because of the dam's unfriendliness. She was seemingly solicitous of the welfare of her young.

LITERATURE CITED

CHAPMAN, A. B., AND L. E. CASIDA. 1935. Length of service period in relation to productive and reproductive efficiency in dairy cows. Amer. Soc. Animal Production Proc.: 66–70.

CLAMOHOY, L. L. 1952. A further study of the breeding habits of cattle. Philippine Agriculturist 35: 478–485.

GAINES, W. L., AND J. R. PALFREY. 1931. Length of calving interval and average milk yield. Jour. Dairy Sci. 14: 294.

MANRESA, M. 1931. Physiology of reproduction in the ox: Changes in the generative organs in open and pregnant heifers and cows. University of the Philippines Nat. and Applied Sci. Bull. 1: 223–248.

MANRESA, M., AND D. DIAPO. 1938. Studies on the breeding habits of cattle. Philippine Agriculturist 26: 870–891.

PERRY, E. J., J. W. BARTLETT, G. E. TAYLOR, J. EDWARDS, C. E. TERRILL, V. BERLINER, AND F. P. JEFFREY. 1945. The artificial insemination of farm animals. 265 p. New Brunswick: Rutgers University Press.

RICE, V. A. 1942. Breeding and improvement of farm animals. 3rd ed., xx + 750 p. New York and London: McGraw-Hill Book Company, Inc.

RICE, V. A., AND F. N. ANDREWS. 1951. Breeding and improvement of farm animals. 4th ed., xii + 787 p. New York and London: McGraw-Hill Book Company, Inc.

RIGOR, T. V. 1949. Red Sindhi cattle: I. Breeding activities. Philippine Jour. Anim. Indus. 10: 143–147.

SARAO, F. B., AND M. MANRESA. 1941. Performance of the Red Sindhi cattle at the College of Agriculture. Philippine Agriculturist 30: 541–547.

VANDEMARK, N. L., AND G. W. SALISBURY. 1950. The relation of postpartum breeding interval to reproductive efficiency in the dairy cow. Jour. Dairy Sci. 9: 307–313.

TABLE 1

*Interval between calving and following oestrus*

| HERD NO. | DATE OF CALVING | DATE OF OESTRUS | INTERVAL |
|---|---|---|---|
| | | | *days* |
| 13 | September 15, 1951 | December 3, 1951 | 79 |
| 1 | May 6, 1951 | February 2, 1952 | 271 |
| 4 | November 3, 1951 | March 3, 1952 | 121 |
| 11 | December 31, 1951 | April 13, 1952 | 104 |
| 10 | November 16, 1951 | April 16, 1952 | 152 |
| 8 | December 26, 1951 | July 25, 1952 | 212 |
| 3 | June 6, 1952 | September 6, 1952 | 92 |
| 7 | July 30, 1952 | September 12, 1952 | 43 |
| 20 | December 28, 1951 | October 5, 1952 | 281 |
| 5 | June 24, 1952 | October 7, 1952 | 105 |
| 22 | February 12, 1952 | November 8, 1952 | 270 |
| 32 | June 8, 1952 | November 24, 1952 | 169 |
| Average ..... | | | 158.2 ± 23.7 |

TABLE 2

*Duration of oestrus*

| HERD NUMBER | | OCCURRENCE OF OESTRUS | TIME | | DURATION |
|---|---|---|---|---|---|
| Cow | Bull | | Start | Termination | |
| | | | | | *hrs.* |
| 13 | R.S. 34 | Dec. 3, 1951 | 6:30 a.m. | 9:30 p.m. | 15.0 |
| 1 | R.S. 34 | Feb. 2, 1952 | 8:00 a.m. | 10:30 p.m. | 14.5 |
| 4 | R.S. 34 | Mar. 3, 1952 | 6:30 a.m. | 10:00 p.m. | 15.5 |
| 11 | R.S. 34 | Apr. 13, 1952 | 6:30 a.m. | 8:30 p.m. | 14.0 |
| 10 | R.S. 34 | Apr. 16, 1952 | 4:00 a.m. | 9:30 p.m. | 17.5 |
| 10 | H.F. 1 | May 27, 1952 | 5:30 a.m. | 4:00 p.m. | 10.5 |
| 9 | H.F. 1 | Aug. 19, 1952 | 10:00 a.m. | 9:30 p.m. | 11.5 |
| 30 | R.S. 18 | Sept. 15, 1952 | 8:00 a.m. | 6:00 p.m. | 10.0 |
| 32 | R.S. 18 | Sept. 24, 1952 | 3:00 a.m. | 3:00 p.m. | 12.0 |
| Average ..... | | | | | 13.4± 0.8 |

TABLE 3

*Interval between oestruses*

| HERD NO. | OCCURRENCE OF FIRST OESTRUS | OCCURRENCE OF SECOND OESTRUS | INTERVAL | OCCURRENCE OF THIRD OESTRUS | INTERVAL |
|---|---|---|---|---|---|
| | | | *days* | | *days* |
| 1 | Feb. 2, 1952 | Feb. 23, 1952 | 21 | Mar. 15, 1952 | 21 |
| 11 [a] | Apr. 13, 1952 | May 2, 1952 | 19 | May 22, 1952 | 20 |
| 10 | Apr. 16, 1952 | May 6, 1952 | 20 | May 27, 1952 | 21 |
| 9 | July 9, 1952 | July 30, 1952 | 21 | Aug. 19, 1952 | 20 |
| 8 | July 25, 1952 | Aug. 21, 1952 | 27 | Sept. 27, 1952 | 37 |
| 13 | Dec. 3, 1951 | Dec. 23, 1951 | 20 | | |
| 30 | Aug. 27, 1952 | Sept. 15, 1952 | 19 | | |
| 3 | Sept. 6, 1952 | Sept. 22, 1952 | 16 | [b] | |
| 20 | Oct. 5, 1952 | Oct. 25, 1952 | 20 | | |
| Weighted average interval ..... 21.3 ± 1.2 days | | | | | |

[a] She had her fourth oestrus on June 10, 1952, and her fifth oestrus on June 30, 1952. The intervals of 19 and 20 days, respectively, were included in computing for the weighted average.

[b] They were served by the breeding bulls on the second oestrus and were impregnated.

# A PLOT TEST OF FIVE STRAINS OF WAGWAG RICE [1]

VALERIANO C. CALMA AND ONOFRE J. CRUZ

Wagwag strain numbers 97, 105, 180, 215, and 396 were subjected to a plot test with common stock seeds as control. The five strains and the control flowered and matured at practically the same time. They were attacked slightly by rice stem borer, *Schoenobius incertellus* Walker, at the blooming stage. The five strains did not differ significantly from the control in height at maturity, number of bearing culms, and yield.

Wagwag, an introduced variety of rice in the College of Agriculture, was found by Abella [2] to be the highest yielder of four varieties. To establish and maintain pure strains from this variety with the ultimate aim of increasing its yield, Callejo [3] undertook the initial selection of strains in this College. He selected 164 strains which were later utilized by Goseco [4] in a plant-to-the-row test. Goseco recommended that 88 strains be further tested for selection of the highest yielding lines. After studying 83 of these productive strains, Carurucan [5] recommended that a plot test be conducted of the five highest yielding strains.

The five strains isolated by Carurucan were tested in this work to find the most productive ones when grown on a larger scale and to study their performance. The work was conducted from June, 1952, to August, 1953, in the Department of Agronomy of the UP College of Agriculture and Central Experiment Station.

## MATERIALS AND METHODS

*Variety and strains.* Two liters each of Wagwag strain numbers 97, 105, 180, 215, and 396 and two liters of Wagwag common stock seeds were used.

*Land.* A portion of lowland rice field with an area of 1500 square meters of clay loam was divided into 18 plots with an area of

[1] Central Experiment Station Contribution No. 1734. Based on the thesis of the junior author presented for graduation in October, 1953, with the degree of Bachelor of Science in Agriculture. Prepared under the direction of the senior author.

[2] Dionisio M. Abella, "A Study of the Performance of Four Varieties of Rice." (Thesis presented for graduation with the degree of Bachelor of Science in Agriculture from the College of Agriculture, 1949. Unpublished.)

[3] Isidro C. Callejo, "Variation and Selection of Wagwag Rice." (Thesis presented for graduation with the degree of Bachelor of Science in Agriculture from the College of Agriculture, 1950. Unpublished.)

[4] Andres D. Goseco, "Plant-to-the-Row Test of Strains of Wagwag Variety of Rice." (Thesis presented for graduation with the degree of Bachelor of Science in Agriculture from the College of Agriculture, 1951. Unpublished.)

[5] Juan J. Carurucan, "Further Selection of Strains of Wagwag Variety of Rice." (Thesis presented for graduation with the degree of Bachelor of Science in Agriculture from the College of Agriculture, 1952. Unpublished.)

76 square meters each. Six plots were alloted to each strain and the control at random and were replicated three times.

*Preparation of the seedbed.* The seedbed was prepared in the ordinary wet-bed method.

*Treatment and sowing of seeds.* On August 2, 1952, the seeds of the five strains and the control were placed in separate gunny sacks. They were soaked in running water for 24 hours and then incubated for another 24 hours before they were sown in the seedbed on August 5, 1952. Care was taken to prevent mixture of the seeds of the different strains during sowing. Part of the water in the seedbed was drained so that the seeds would settle evenly in the mud and be kept from rotting. The seeds were broadcast at the rate of 25 gantas to a hectare.

*Preparation of the field for transplanting.* The field was plowed with a native plow, and water was turned into the paddies. The field was harrowed lengthwise, then crosswise, with a native harrow and was finally harrowed and leveled before transplanting.

*Selection and treatment of seedlings for transplanting.* On September 19, 1952, the average heights of 30 vigorous seedlings of each strain and the control taken at random were recorded. Water was turned into the seedbed before the seedlings were pulled. The seedlings were pruned to about one-third of their heights to minimize transpiration.

*Transplanting and replanting.* On September 19, 1952, the 45-day-old seedlings were transplanted in the ordinary lowland method, two to three seedlings to a hill at a distance of about twenty-five centimeters each way. Two weeks after transplanting, all the hills where the plants had died were replanted.

*Care of the plants.* The plants were not watered after transplanting so that the seedlings could establish themselves in the soil. As water was maintained only with great difficulty in the plots, the weeds threatened to interfere with the growth of plants; hence, the plots were weeded whenever necessary until the plants were tall enough to cover the weeds.

*Field observation.* The germination in the seedbed and in the laboratory of the five strains and the control was noted. The appearance of the seedlings in the seedbed and in the transplanted field, the age and height of the seedlings until transplanting, the period from sowing to flowering, the period from sowing to maturity, the tendency to lodge, the tillering capacity, and the presence of pests and diseases were observed.

*Harvesting, threshing, and winnowing.* Harvesting was done from February 12 to 16, 1953, when the majority of the plants in each plot had matured. The plants were cut about 50 centimeters above the ground with a *lilik* or scythe. The harvests from the different plots were threshed separately; the panicles were trampled

on a mat laid on the ground. The palay was partially cleaned of trash in the field before it was placed in sacks and brought to the laboratory for drying prior to cleaning and weighing. The remaining trash in each strain was removed with a winnowing machine. The weight of the palay in kilograms was recorded before and after winnowing.

*Milling.* Five gantas of cleaned palay of each strain and the control were milled in a rice mill.

## RESULTS AND DISCUSSION

*Field observation: In the seedbed.* Three days after sowing, a heavy rain submerged the plots and caused uneven germination of the seeds of strain numbers 105 and 215 and the control. All the seeds germinated five days after sowing. Because of the lack of water, practically all the seedlings of the different strains and the control were stunted in growth 11 days after germination. The seedlings were pale and wilted in the afternoon. Two weeks later, however, rain fell and enabled the plants to recover faster. One month after sowing, the seedlings began to show slight differences in height and growth. The seedlings of the five strains were observed to be more uniform in height than those of the control.

The average heights in centimeters of 30 seedlings of each strain and the control taken at random when they were 45 days old were as follows: strain 97, 2.80; strain 105, 31.37; strain 180, 29.43; strain 215, 31.47; strain 396, 30.27; and the control, 32.93.

*In the transplanted field.* The seedlings recovered five days after transplanting. There were no marked differences in growth and vigor among the five strains one month after transplanting. The plants of strain 180 appeared to be the most uniform in growth and vigor in all replications.

All the plants of each strain and the control lodged at maturity because of the increased weight of the panicles.

Among the pests that attacked the plants was the rice stem borer,[6] *Schoenobius incertellus* Walker. It caused the appearance of white dried panicles with empty grains. The damage, although regarded as being too small to affect materially the yields of the five strains and the control, was fairly well distributed in all the plots.

*Height of plants at maturity.* The heights of the five strains and the control did not differ significantly from each other (table 2).

*Number of bearing culms.* The mean number of bearing culms to a hill at maturity ranged from 15.9 ± 0.3 to 18.0 ± 0.6. The number of bearing culms of strain 97 gave a statistically significant difference when compared to that of the control.

*Blooming and maturity periods.* The five strains and the control flowered from 156 to 162 days and matured from 188 to 195 days after sowing (table 1).

[6] Identified by Dr. Silverio Cendaña of the Department of Entomology.

*Percentage of filled grains.* The percentages of filled grains of the five strains and the control are shown in table 3.

*Milling percentage.* The milling percentages of the five strains and the control are shown in table 5.

*Yield.* The differences in yield of the five strains and the control were insignificant (table 4). On the basis of 44 kilograms a cavan, the computed yields in cavans to the hectare were as follows: strain 97, 77.25; strain 105, 74.26; strain 180, 72.66; strain 215, 77.22; strain 396, 74.36; and the control, 71.97.

The increase in yield of clean palay to a plot of the five strains over the control ranged from 0.99 to 7.37 per cent. The increase in yield of clean rice of the five strains over the control ranged from 0.41 to 24.85 per cent. These increases, however, were not significant.

TABLE 1

*Days from planting to blooming and to maturity*

| WAGWAG RICE | DAYS FROM SOWING TO FLOWERING | DAYS FROM SOWING TO MATURITY |
|---|---|---|
| Strain No. 97 | 156 | 188 |
| " " 105 | 159 | 188 |
| " " 180 | 159 | 191 |
| " " 215 | 162 | 191 |
| " " 396 | 158 | 195 |
| Control | 162 | 189 |

TABLE 2

*Mean number of bearing culms and mean height of plants*

| WAGWAG RICE | NUMBER OF BEARING CULMS [a] | HEIGHT OF PLANTS IN CENTIMETERS [b] |
|---|---|---|
| Strain No. 97 | 17.9 ± 0.5 | 132.3 ± 0.6 |
| " " 105 | 18.0 ± 0.6 | 131.9 ± 0.5 |
| " " 180 | 17.6 ± 0.5 | 132.0 ± 0.8 |
| " " 215 | 15.9 ± 0.3 | 131.1 ± 0.5 |
| " " 396 | 17.9 ± 0.4 | 130.7 ± 0.4 |
| Control | 16.7 ± 0.5 | 130.0 ± 1.0 |

[a] Based on 60 plants.
[b] Based on 30 plants.

TABLE 3

*Weight of palay and percentage of filled grains*

| WAGWAG RICE | WEIGHT OF PALAY | | PERCENTAGE |
|---|---|---|---|
| | Uncleaned | Cleaned | |
| | *kg.* | *kg.* | |
| Strain No. 97 | 28.06 | 25.83 | 92.05 |
| " " 105 | 26.83 | 24.83 | 92.55 |
| " " 180 | 25.93 | 24.30 | 93.71 |
| " " 215 | 27.93 | 25.83 | 92.48 |
| " " 396 | 27.26 | 24.46 | 89.73 |
| Control | 26.26 | 24.06 | 91.62 |

TABLE 4

*Yield of clean palay in kilograms*

| WAGWAG RICE | REPLICATION | | | TOTAL | MEAN |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | | |
| Strain No. 97 | 23.5 | 24.2 | 29.8 | 77.5 | 25.83 |
| " " 105 | 23.7 | 26.6 | 24.2 | 74.5 | 24.83 |
| " " 180 | 25.0 | 23.4 | 24.5 | 72.9 | 24.30 |
| " " 215 | 24.5 | 26.2 | 26.8 | 77.5 | 25.83 |
| " " 396 | 24.8 | 24.2 | 25.6 | 74.6 | 24.86 |
| Control | 25.9 | 21.7 | 24.6 | 72.2 | 24.06 |
| Total | 147.4 | 146.3 | 155.5 | 449.2 | |

*Analysis of variance*

| SOURCE OF VARIATION | DF | SUM OF SQUARES | MEAN SQUARES | COMPUTED F-VALUE | TABULAR F-VALUE | |
|---|---|---|---|---|---|---|
| | | | | | 0.05 | 0.01 |
| Replication | 2 | 8.42 | 4.21 | | | |
| Strain | 5 | 8.35 | 1.67 | 0.48 | 3.33 | 5.64 |
| Error | 10 | 34.66 | 3.47 | | | |
| Total | 17 | 51.42 | | | | |

TABLE 5

*Milling percentage based on five gantas*

| WAGWAG RICE | WEIGHT | | PERCENTAGE |
|---|---|---|---|
| | Palay | Cleaned rice | |
| | *kg.* | *kg.* | |
| Strain No. 97 | 9.1 | 6.3 | 69.23 |
| " " 105 | 9.0 | 5.5 | 61.11 |
| " " 180 | 9.0 | 6.2 | 68.89 |
| " " 215 | 8.9 | 5.6 | 62.92 |
| " " 396 | 9.5 | 5.5 | 57.89 |
| Control | 8.9 | 5.3 | 59.55 |

# CASE REPORT: ANTHRAX IN THE UP COLLEGE OF AGRICULTURE [1]

G. V. Garcia

The natural topography of the UP College of Agriculture minimizes to a considerable extent contact between the College herds and those on the outside. In addition, quarantine regulations governing the segregation of animals which are sick and those which are newly introduced are strictly enforced. Thus, the sudden death from anthrax of a very valuable Brown Swiss cow owned by the College caused no little amount of anxiety and consternation, especially since the disease is transmissible to man.

## SUBJECT

The subject was a Brown Swiss cow, mouse brown in color and 130 centimeters in height.

## HISTORY

The Brown Swiss cow, together with eight other females and a bull, also of the same breed, was immediately quarantined upon arrival in the College on May 17, 1953. Blood samples from the group were submitted to the Bureau of Animal Industry in Manila for contagious abortion test. The animals were released 30 days later. As the blood test for the Brown Swiss cow and the bull was unsatisfactory, these two animals, upon advice of the bureau, were again isolated on July 7 for another test. The cow died on August 5 while in confinement.

## SYMPTOMS

The cow, which was due to calve, was apparently normal the day before her death. Her appetite was good, and her disposition bright. At about 6:40 a.m. the following day, however, the animal was observed to be restless and behaving strangely. She would stamp her feet and bellow, all the while moving around the stall aimlessly. Besides having a dry muzzle and congested conjunctiva, the cow had accelerated respiration. Muscular tremors were also observed. Finally when death was about to supervene, the animal, with one convulsive effort, executed a circle with the hind legs serving as pivot and on completion of this motion, fell with the legs wide apart and the head resting on a feeding trough.

## POST-MORTEM FINDINGS

*External appearance.* Rigor mortis, although incomplete, was present. The eyelids were partly closed, and the conjunctival mucous membrane, hyperemic. The rectum was prolapsed and hemorrhagic. A dark, bloody discharge oozed out from both anus and vulva.

*Internal appearance.* The most striking lesions noted were the extensive serous infiltrations and bloody extravasations in the sub-

[1] Central Experiment Station Contribution No. 1735.

cutaneous and muscular tissues. These were mostly of the diffuse type and were more numerous in the regions of the thigh, shoulder, and intercostal muscles adjacent to the sternum. Similar changes were also noted in the mediastinum of the pleura, mesentery, and around the perirenal region. A reddish fluid was found in both the pleural and peritoneal cavities. The blood was dark red and coagulated imperfectly. No changes were observed in the compound stomach. However, there was hemorrhagic enteritis. The body lymph glands, except the popliteal, were markedly swollen and dark red. On sectioning, the cut surfaces were found to be sprinkled with small hemorrhages. The apical, cardiac, and diaphragmatic lobes of both lungs were severely affected with extensive hemorrhages of various sizes. The air passages and, more specifically, the region of the larynx were hyperemic. Similar findings were observed in the heart; extensive hemorrhages, both circumscribed and diffused, were found in the pericardium, coronary fat, and endocardium. The liver appeared normal. The gall bladder, however, was greatly distended and hemorrhagic. There was acute splenitis; the organ appeared larger than its normal size and was soft and hemorrhagic.

As cited earlier, the cow was a suspected brucella abortus case when it died. When the uterus was opened, a yellowish exudate filling up the uterine cavity and almost entirely covering the fetus was found. The mucous linings of the uterus and placenta were congested.

### ANATOMICO-PATHOLOGICAL FINDINGS

Extensive sero-sanguino infiltrations of the connective tissues in different parts of the body (subcutaneous, muscular, mediastinum, mesentery, and the neighborhood of the kidneys), hemorrhagic lymphadenitis, acute splenitis, hemorrhagic enteritis, acute pneumonia with hyperemia of the air passages, hemorrhagic pericardio-endocarditis, placentitis, and endometritis with accumulation of a yellowish exudate in the uterine cavity were found.

### SOURCE OF INFECTION

A number of theories were offered to explain how the cow contracted anthrax. One is that the disease was transmitted by blood-sucking flies and mosquitoes. A second theory is that it was incurred through wound infection. A third is that the disease was a result of vaccinating the animal with live attenuated cultures of bacillus anthracis prior to its arrival in the Philippines. Another theory is that the disease was contracted through soil infection. This last explanation was formulated after bones, mostly of horses, were discovered while a burial pit was being excavated in the place were the cow died. Investigation disclosed that the site used to be a burial ground for animals which the Japanese forces brought with them when they occupied the College campus during the last war. Considering all aspects of the case, the last explanation appears to be the most plausible, although no actual attempt was made to demonstrate cultures of the anhrax bacillus.

## COLLEGE AND ALUMNI NOTES

Dr. I. J. Dumbleton, plant and animal quarantine officer of the South Pacific Commission, Noumea, New Caledonia, and Miss Brenda Bishop, assistant secretary of the Pacific Science Council Secretariat, Honolulu, Hawaii, visited the College on September 7, 1953. They were accompanied by Dean Patrocinio Valenzuela, secretary-general, Eighth Pacific Science Congress. Doctor Dumbleton was on a two-day stopover on his return trip to New Caledonia. Miss Bishop has been detailed from Honolulu by the Pacific Science Association to help in the preparation for the Eighth Pacific Science Congress, which will be held in the Philippines from November 16 to 28, 1953.

Dr. Valente Villegas and Dr. Gonzalo V. Garcia, of the Department of Animal Husbandry, were speakers at the two hundred eighteenth scientific meeting of the Los Baños Biological Club held in the Chemistry Lecture Hall on August 28, 1953. Dr. Villegas read and discussed "Durability of Ropes for Tethering Cattle" and Dr. Garcia, "Intestinal Calculi in a Native Horse."

At the meeting of the Los Baños Biological Club on September 25, 1953, a paper of Dr. F. T. Orillo and Mr. S. Quiniones, entitled "Blight of Kenaf," was read and discussed.

Dr. John K. Loosli, visiting professor of animal nutrition from Cornell University who recently joined the staff of the Department of Animal Husbandry, was the guest speaker at the Eighth Seminar held under the auspices of the Animal Husbandry Division, Bureau of Animal Industry, on August 29, 1953.

Mr. Phisit Sukhavanija, a former student of this College and now with the Oriental Life Assurance Ltd., Thailand, visited the campus on August 29, 1953. He was accompanied by Mr. Percy A. Roa, of the Insular Life Assurance Co. Ltd., Manila.

Mr. L. E. Peter, of the South Pacific Commission, Noumea, New Caledonia, and Dr. Barker H. Brown, of Macondray and Company, Manila, visited the College on August 24, 1953.

A parade and review in honor of the deans and faculty members of the Colleges of Agriculture and Forestry was held by the local ROTC unit on August 24, 1953. Captain M. V. Maligalig is the present commandant.

Three members of the faculty left by plane on September 9, 1953, for the United States to pursue advanced studies under the FOA-PHILCUSA technical assisance program. They are Dr. Faustino S. Mensalvas and Messrs. Pedro B. Escuro and Thomas G. Flores.

Messrs. Laureano O. Bondoc, Antonio D. Bustrillos, Valentin G. Cedillo, and Emilio U. Quintana, also instructors in the College, left

by plane on September 16, 1953, to pursue advanced studies and visit agricultural institutions under the same program.

The Ranchers' Club celebrated its field day on August 22, 1953, at the Animal Husbandry compound with an open forum and a field program. Mr. Querobin Dycoco is the governor and Mr. Amado C. Campos, the adviser of the organization.

Dr. Amando M. Dalisay, '37, executive secretary of the PHILCUSA, was appointed Acting Undersecretary of Agriculture and Natural Resources by the President of the Philippines during the absence of Mr. José S. Camus, '14, who is in the United States.

Attorney Cornelio V. Crucillo, '25, technical adviser and coordinator of projects of the PHILCUSA, represented the Philippines at the Ninth Congress of the International Institute of Administrative Sciences, which was held in Istanbul, Turkey.

Dr. José R. Mondoñedo, '49, returned after an absence of about three years, during which he took graduate work in tobacco agronomy at the University of Maryland, first as a Fulbright scholar and later as a UP fellow. He brought back with him two degrees (M.A. and Ph.D.) and a wife, the former Miss Amelia Perez. Doctor Mondoñedo rejoins the staff of the Department of Agronomy of the College.

Mr. Jose Crisanto, '23, of the Bureau of Public Schools, accompanied Mr. Clavis R. Wilkey, FOA vocational agriculture specialist, and Mr. Robert A. Manire, also of the FOA when they visited the College on September 2, 1953. Mr. Manire was particularly interested in swine husbandry.

Mr. Carlos A. Calica, '38, assistant plant pathologist of the Bureau of Plant Industry, stationed at the Guinobatan Experiment Station, Albay, is temporarily assigned to work with Dr. G. C. Kent and Dr. G. O. Ocfemia in connection with the research on cadang-cadang of coconut in the Department of Plant Pathology of the College. Mr. Calica is taking the place of Mr. Orencio M. Lawas, '49, who has accepted a scholarship in Italy to study rice culture. His assignment in the College is in line with the cooperative program between this institution and the Bureau of Plant Industry.

Messrs. Lamberto J. Tolentino, '47, and Lorenzo C. Zuñiga, '53, both of the Quezon Coconut Experiment Station in Tiaong, Quezon, were campus visitors. Mr. Tolentino is assistant horticulturist and Mr. Zuñiga, assistant plant breeder, of the station.

Several members of the Class of 1953 have joined the staff of the Office of Agricultural Economics, Department of Agriculture and Natural Resources. They are Messrs. Melchor F. Constantino and Marcos M. Nuestro and Misses Lilia V. Hosillos and Corazon P. Salamat.

The thirty-fifth Loyalty Day anniversary was celebrated on October 10, 1953, with Mr. Harry A. Brenn, chief of the STEM-FOA,

as guest of honor. Upon his arrival at the campus gate, he inspected the escort of honor. Then followed a parade. The floats depicted a central theme: "Progress through Agricultural Research and Education." After the parade, a literary-musical program was held at Baker Memorial Hall. Luncheon was served at noon to guests and visiting alumni. Basketball games were held in the afternoon. A dance in the evening under the auspices of the student body closed the celebration.

This year's Loyalty Day celebration was attended by a large number of out-of-town alumni. Those who signed the alumni register were the following: Class of 1911—José F. Zamora; 1914—Gonzalo F. Merino; 1915—Agripino Constantino, Jose J. Mirasol, Pedro Montellano, Nicanor G. Teodoro; 1916—Marcelino Constantino, Florentino F. Cruz; 1918—Claro Samonte, Anastacio L. Teodoro; 1919—Antonio Chanco, Emiliano F. Roldan, Juan P. Torres; 1920—Rufino Isidro, Nemesio A. Catalan, Ambrosio M. Lontok; 1921—Francisco C. Bernardo; 1922—Eulalio P. Baltazar, Basilio L. Hernandez, Quirino P. Ricafrente, Basilio Q. Viado, Severo G. Yap; 1923—Emilio C. Aquino; 1924—Epifanio Enerva, Mamerto E. Limuaco, Canuto G. Manuel, Clemente Yango; 1925—Cornelio V. Crucillo, Eugenio E. Cruz; 1927—Quintin A. Eala; 1928—Dominador Rosell, Felix F. Villa; 1929—Martin S. Celino, Federico S. Isaac, Felixberto Relova; 1930—Artemio E. Gesmundo, Epitacio A. Lanuza, Jacinto B. Leoncio, Jesus P. Mamisao, Pascual M. Matulac, Manuel B. Villano; 1931—Santiago R. Capco, Gaudencio B. Cruz, Juan O. Sumagui; 1932—Porfirio R. Manacap, Andres M. Mane, Juan B. Rozul; 1933—Proceso E. Alcala, Antonio B. Cecilio, Alberto C. Elepaño, Salvador B. Oliveros; 1934—Jose K. Santiago, Generoso F. Tanseco, Alfonso L. Tecson, Alejandro R. Apacible, Cesar T. Mamon; 1935—Vicente Arancillo, Pedro M. Asico, Dominador E. Batenga, Venancio C. Duarte, Cenon R. Flor Cruz, Mariano S. Macasaet, Pantaleon P. Opeña, Fabian O. Sulpico; 1936—Nicanor M. Alvaro, Leandro R. Lopez, Cornelio B. Macabasco, Flaviano P. Olivares, Aquilino V. Platon, Hector A. Rivera, Ignacio E. Villanueva; 1937—Jose V. Castillo, Crispin Dacanay, Leona Atienza-Dacanay, Amando M. Dalisay, Conrado C. Dinulos, Romeo C. Espino, Celestino B. Quilang; 1938—Manuel A. Aaron, Antonio Gianzon, Severino S. Diaz, Magno M. Mamañgon; 1939—Carlos A. Calica, Angel C. Gallardo, Felipe R. Lopez, Ascario G. Tuason; 1940—Bernardo C. Castillo, Alfonso B. Castro, Ramon Samaniego; 1941—Felipe A. Maclang, Isidoro B. Romero, 1942—Felipe P. Barile, Adolfo V. A. Lim; 1943—Ciriaco S. Celino, Elpidio F. Galado; 1944—Justo C. Gonzales, Jr., Nelia Teodoro-Gonzales, Romeo P. Martinez, Santos G. Llana, Federico V. Ramos, Benjamin J. Samala; 1945—Eleazar M. Galano, Jorge V. Villegas; 1946—Rufo H. Ocfemia, Norberto C. Palis; 1947—Simeon M. Alejandro, Juan C. Bunoan, Jr., Feliciano J. Garcia, Ciriaco M. Lawas, Lydia Catalan-Saguiguit, Jesus Moran Sison, Felix Villamayor; 1948—Patricio Y. Agbagala, Renato Capinpin, Magdaleno R. Elazegui, Eugenio A. Jongo, Restituto

R. Lopez, Nena A. Rola-Bustrillos; 1949—Roberto M. Amaba, Avelino E. Bigornia, Ildefonso M. Cruz, Sofronio C. Escober, Silvestre V. Javier, Jr., Fabiana Alviar-de Leon; 1950—Tranquilino C. Alambra, Antonio U. Serraon, Manuel de Leon, Jr., Leandro G. Sinco, Eliseo Trinidad; 1951—Rosario A. Aspiras, Gloria C. Bandong, Amado C. Garcia, Manuel C. Iñigo, Oscar Mabanag, Juanito G. Odejar, Antonio C. Pizarro, Orlando G. Santos, Efren B. Sibayan, Nestor C. Vera Cruz; 1952—Vito F. del Fierro, Jr., Roman L. Lucas, Deogracias V. Maligalig, Felino B. Rivera; 1953—Perfecta L. Barile, Romeo V. Aquino, Pedro S. Cariaga, Agustin T. de Castro, Marcelo V. Catalan, Lydia A. Clemente, Demetria B. Fernandez, Sebastian Quiniones, Reynalda Carañgal-Ramos, and Juanito S. Sarmenta.

Alumni who could not attend the celebration sent by telegram or letter their greetings and pledges of loyalty. Among them were the following: Bienvenido M. Gonzalez, '13, Manuel S. Mallorca, '51, Felipe T. Aala, '34, Rasuman Macalandong, '36, Jose T. Tapay, '45, Isidro S. Domingo, '51, Eulogio Rodriguez, '25, Pablo N. Mabbun, '23, Flaviano Pagador, '51, Teodoro A. de Jauregui, '51, Dionisio M. Abella, '51, Alexander Gordon, '23; aggies at Central Luzon Agricultural College—Arcadio G. Matela, '29, Vicente M. Dawis, '16, Juan I. Nerio, '21, Constantino Derecho, '27, Jose A. Serrano, '27, Perico Y. Arcedo, '33, Briccio O. Reynoso, '33, Macario P. Corales, '34, Crispino R. Las Maria, '36, Cornelio S. Binoya, '39, Elias C. Neypes, '40, Feliciano L. Cruz, '41, Alfonso N. Eusebio, '44, Celestino P. Habito, '44, Pedro A. Abella, '48, Pedro N. Laudencia, '48, Teodoro A. Irabagon, '49, Jose C. Alonzo, '51, Raymundo E. Jovellanos, '51, Quirino N. Villaviza, '53; Bohol fertilizer supervisors—Isidro L. Madjus, '26, Eduardo A. Artiaga, '47, Marcelino S. Lumayag, '49, Brigido Narit, '53, Felipe Cagampang, '53; alumni in training conference at Gandara Seed Farm—Alberto Dalañgin, '51, Felipe Padolina, '18, Ramon Manio, '19, Antonio Derecho, '20, Pablo Macariola, '35, Diosdado Boñgato, '33, Antonio Durano, '27, Rufino Ayaso, Jr., '52; aggies at Victorias—Abelardo Bantug, '35, Manuel L. Hollero, '41, Pedro P. Porquez, '26, Filomeno Tabayoyong, '47, Marcial Alviar, '49, Domingo Molina, '53, Jose Miraflores, '15, Eugenio Agudo, '31, Ludovico N. Tayag, '53, Irving P. Villasor, '53; alumni in U.S.A.—Zacarias Valdez, '44, Rafael Martelino, '51, Francisco C. Bandong, '52, Valentin G. Cedillo, '42; and Constancio T. Medrana, '27, and alumni in his faculty at Mountain National Agricultural School.

Other alumni in the U.S.A. who sent greetings on the occasion of Loyalty Day were Messrs. Virginio C. Juan, '35, Rufo D. Dacanay, '36, and Felix V. Remigio, '38. They are pursuing studies at the Pennsylvania State College as FOA-PHILCUSA trainees.

Others who sent felicitations were Secretary Juan Salcedo, Jr.; Mr. John Hepler, of FOA; Dean Domingo Nolasco, who reported that about 50 Los Baños alumni were celebrating Loyalty Day at the UP Iloilo College; and Messrs. Tizon, Suarez, Laguna, and Lopez, of Victorias Milling Company.

Additional professors from Cornell University recently arrived on the campus. They are Dr. Paul Work, visiting professor of vegetable gardening, and Dr. James L. Brewbaker, visiting assistant professor of plant breeding.

Drs. Warren Weaver, J. G. Harrar, and J. Ranson Ebberson, of the Rockefeller Foundation, visited the College on September 22, 1953. They were accompanied by Mr. Joseph L. Dougherty, agricultural attaché of the U. S. Embassy, and Dean Leland E. Call.

Dr. Herbert K. Hayes, a member of the Cornell group, was the guest speaker at an Arbor Day program in the Rural High School on September 14, 1953. After the literary-musical program, a tree was planted by Doctor Hayes with the help of officers of the senior class organization.

Mr. Forrest H. Turner, Mr. Cayetano C. Pineda, Mr. and Mrs. A. J. Brundage, of STEM-FOA in Taipeh, Formosa, and Col. Alfredo C. Sese were campus visitors on September 18, 1953. They were accompanied by Dean Leland E. Call.

The Los Baños chapter of the UP Beta Sigma Fraternity held a dance in honor of Miss Felicitas Palis, sweetheart, and the new brothers at the Forestry Pavilion on September 12, 1953. Vicente Saplala is the president and Mr. Amado C. Campos is the adviser of the fraternity.

The College Dormitory residents held a barn dance at the Molawin Hall on September 5, 1953. Crispino Sagrado is the president and Dr. S. M. Cendaña is the adviser of the group.

Dr. Juan P. Torres, '19, of the Bureau of Plant Industry, was designated Philippine representative to the fourth meeting of the working party on rice breeding in Bangkok.

The Standing Committee on Sugar Cane Diseases and Their World Distribution appointed at the Seventh Congress of the International Society of Sugar Cane Technologists held in Brisbane, Australia, in 1950, consisting of J. P. Martin, Hawaii, chairman; E. V. Abott, Louisiana, U.S.A.; R. E. D. Baker, British West Indies; Luis A. Alvarez Garcia, Puerto Rico; J. W. Hes, Java; C. G. Hughes, Australia; T. T. Lo, Taiwan; A. McMartin, South Africa; G. O. Ocfemia, Philippines; and G. Orian, Mauritius, was reappointed at the Eighth Congress of the I.S.S.C.T. held in the British West Indies in 1953. The following new members were added: S. C. Arruda, Brazil; B. A. Browne, Florida, U.S.A.; B. L. Chona, India; Perry E. Robinson, Fiji; E. M. Summers, Cuba.

President Elpidio Quirino visited the College on October 25, 1953, and spoke before an audience composed of faculty, students, public school teachers, and nearby residents. He was accompanied by Mr. Jose Yulo, President Vidal A. Tan of the University, Acting Undersecretary of Education Benito Pañgilinan, and others.

Mr. T. E. Haynes, assistant director of programming, FOA, accompanied by Dean L. E. Call, visited the College and observed the progress of the FOA program in the institution.

Other recent visitors were Mr. Frank E. Moore, FOA specialist in poultry, and Dr. H. E. Baladad, of San Miguel Brewery. They conferred with Dr. Fronda on problems of poultry farmers.

Dr. Lillian Gilbreth, world-famous management consultant, visited the College on September 9, 1953, and spoke at a special convocation. In her party were Prof. and Mrs. Dan Braum, Mr. Heady, and Mr. Emerson. Doctor Gilbreth is adviser of the UP Institute of Public Administration on management problems.

Doctors Joseph E. Walker and Lawrence C. Kapp, of FOA, and Dr. Juan P. Torres and Messrs. Marcelino Constantino and Fabiano O. Sulpico, of the Bureau of Plant Industry, visited the College to see and discuss the present rice and corn improvement work that is being carried out by this group in cooperation with Doctors Umali and Hayes of the Division of Plant Breeding, Department of Agronomy.

Miss Mary C. Wilsie and Mr. William P. Thrall, traveling on the 4-H student trainee program, were recent campus visitors. They were accompanied by Messrs. Francisco Pañganiban and Basilio Viado, both of the Bureau of Agricultural Extension.

Dr. and Mrs. Albino Sycip were recent campus visitors. They were accompanied by Mr. and Mrs. Justo C. Gonzales, Jr., of the Araneta Institute of Agriculture. It will be remembered that Mr. Sycip donated to the College several years ago two electric battery brooders and seven incubators for the use of the students. Incidentally, Mr. Gonzales, who is a graduate of this College, Class 1944, returned very recently from a six-month training in England under the Colombo Plan. Mrs. Gonzales, *nee* Nelia E. Teodoro, is also a graduate of this College, Class 1944. The party was taken around the Poultry Plant by Dr. F. M. Fronda.

Lectures and demonstrations were given by Dr. F. M. Fronda, assisted by Mr. Amado C. Campos, on October 3, 1953, to a delegation of poultry breeders and members of the Philippine Poultry Association participating in the Philippine Poultry Improvement Plan. The lectures centered on culling and selection for egg production.

Dr. F. M. Fronda was one of the speakers at the Poultry Institute held in San Isidro, Nueva Ecija, on October 15, 1953. The institute was attended by leading poultry raisers in the province.

Mr. Benjamin Samala, '44, returned recently from the United States. He obtained a Master's degree in dairy manufactures from Cornell University.

Mr. Ulpiano V. Madamba, '24, is the associate agronomist in charge of the BPI Luna Tobacco Experiment Station in Mountain Province. With him is Mr. Leon B. Edrozo, '17, junior agronomist.

Mr. Federico O. Cabrillas, '43, agronomist, is at present in charge of the Tumanini Tobacco Sub-station in Isabela.

Mr. Roman Anday, '49, was a recent campus visitor. He is on the faculty of Batac Rural High School, Ilocos Norte.

Mr. Cesar T. Loreto, '46, visited the campus recently. Formerly on the faculty of the Baybay High School in Leyte, he is at present with the Bureau of Soil Conservation.

The total enrollment in the College of Agriculture for the second semester, 1953-1954, is 1544, excluding 70 cross-registrants from the College of Forestry. The total enrollment in the second semester, as compared to that of the first semester of this academic year, is classified as follows:

| | *First semester* | *Second semester* | *Difference* |
|---|---|---|---|
| 1. First year (Freshmen) | 765 | 677 | − 88 |
| (a) Old students | (48) | (141) | — |
| (b) New students | (717) | (36) | — |
| 2. First year (Home Technology curriculum) | 42 | 47 | + 5 |
| (a) Old students | — | (45) | — |
| (b) New students | (42) | (2) | — |
| 3. Second year (Sophomores) | 398 | 373 | − 25 |
| (a) Old students | (392) | — | — |
| (b) New students | (6) | — | — |
| (c) Seniors, Associate in Agriculture | 15 | 10 | − 5 |
| 4. Second year (Home Tech. curriculum) | 28 | 25 | − 3 |
| 5. Third year (Juniors) | 195 | 213 | + 18 |
| (a) Old students | (193) | — | — |
| (b) New students | (2) | — | — |
| 6. Third year (Home Tech. curriculum) | 15 | 17 | + 2 |
| 7. Fourth year (Seniors) | 156 | 164 | + 8 |
| 8. Postgraduates | 22 | 15 | − 7 |
| 9. Special students | 1 | 3 | + 2 |
| (a) Old student | — | (1) | — |
| (b) New students | (1) | (2) | — |
| Totals | 1,637 | 1,544 | − 93 |

The College is appealing to its alumni for donation of the following issues of *The Philippine Agriculturist* to complete its collection in the College Library.

| | | |
|---|---|---|
| Vol. | I | (1911) nos. 1, 3, 4, 5, 6, 7, 8, 9, 10. |
| | II | (1912) nos. 1, 2, 3. |
| | III | (1914) nos. 1, 2, 3, 4, 5, 7. |
| | IV | (1915) nos. 1, 4. |
| | VIII | (1919) nos. 1, 2. |
| | IX | (1921) nos. 6, 7. |
| | X | (1921-22) nos. 1, 5, 6, 7, 8, 9, 10. |
| | XI | (1922) nos. 1, 2. |
| | XII | (1923-24) nos. 1, 5, 9. |
| | XIII | (1924) no. 2. |
| | XVI | (1927) nos. 1, 5. |
| | XVII | (1928) nos. 1, 2, 3, 4, 5. |
| | XXVIII | (1939-40) nos. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, Index. |
| | XXIX | (1940-41) nos. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, Index. |
| | XXX | (1941) nos. 1, 2, 3, 4, 5, 6, 7, June-Dec. |

# THE CENTRAL EXPERIMENT STATION

LIST OF AVAILABLE PUBLICATIONS

No. 2.—Bud Rot of Coconut ..... *By G. O. Ocfemia*
No. 8.—Horse Breeding in the Philippines ..... *By V. Villegas*
No. 11.—The New College Copra Drier ..... *By Moises M. Kalaw* (Revised)
No. 17.—College Trapnest ..... *By F. M. Fronda and P. S. Paje*
No. 18.—Surveying for Area with a Surveyor's Staff ..... *By Alexander Gordon*
No. 23.—Curing Pork and Making Sausage for Home Use ..... *By Mariano Mondoñedo*
No. 24.—Construction and Operation of Silos in the College of Agriculture ..... *By J. P. Esguerra*
No. 29.—Collegiate Education in Agriculture ..... *By Leopoldo B. Uichanco*
No. 30.—What Should Filipino Ornamental Gardens and Ornamental Plants Be? ..... *By N. B. Mendiola*

The price of the circulars listed above is thirty centavos (P0.30) each.

All orders for circulars with payment should be addressed to the Business Manager, THE PHILIPPINE AGRICULTURIST, College, Laguna, Philippines.

---

PHILIPPINE AGRICULTURE, Volume 1 { Cloth bound ..... P10.00; Postage ..... 0.40

Volume 2 { Cloth bound ..... P7.00; Postage ..... 0.40

A MANUAL OF PLANT BREEDING FOR THE TROPICS ..... P6.00

All orders for books with remittance should be addressed to:

THE DEAN AND DIRECTOR
COLLEGE OF AGRICULTURE AND
CENTRAL EXPERIMENT STATION
COLLEGE, LAGUNA, PHILIPPINES

# The Philippine Agriculturist

(Formerly The Philippine Agriculturist and Forester)

*Published by the* COLLEGE OF AGRICULTURE
AND CENTRAL EXPERIMENT STATION
UNIVERSITY OF THE PHILIPPINES

Vol. I—2

Vol. III—9-10

Vol. V—2, 6, 7, 9, 10

Vol. VI—1, 2, 3, 4, 6, 7, 8, 9, 10

Vol. VII—complete

Vol. VIII—3, 4, 5, 6, 8-9, 10

Vol. IX—3, 4-5, 8-9

Vol. XI—3, 7, 8

Vol. XIII—1, 10

Vol. XIV—1, 2, 3, 4, 5, 6, 7, 9, 10

Vol. XV—complete

Vol. XVI—3, 8, 9, 10

Vol. XVII—6, 7, 8, 9, 10

Vol. XVIII—complete

Vol. XIX—complete

Vol. XX—complete

Vol. XXI—complete

Vol. XXII—complete

Vol. XXIII—1, 2, 3, 4, 6, 7, 8, 9, 10

Vol. XXIV—complete

Vol. XXV—complete

Vol. XXVI—complete

Vol. XXVII—complete

Vols. XXVIII, XXIX, and XXX—burned

Vols. XXXI, XXXII, XXXIII, and XXXIV—complete

Back copies of Vols. I to XXVII sell at 50 centavos and back copies of Vols. XXXI to XXXIV sell at ₱1.50.

Consolidated index (Vols. I to XX) 50 centavos excluding postage.

Send your order to the BUSINESS MANAGER, THE PHILIPPINE AGRICULTURIST, COLLEGE, LAGUNA, PHILIPPINES.